Radial Frames.

نسألكم الدعاء

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اذا حملت تطبيق RC Structures YASSER EL LEATHY على تليفونك المحمول او اللوح السطحى ستستطيع أن تشغل أفلام شرح للمقاطع التى تحتوى على رمز

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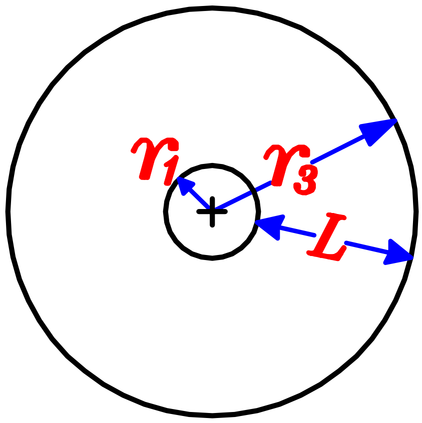
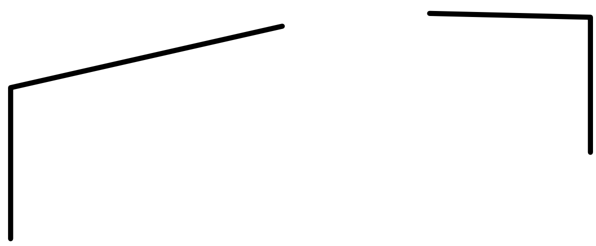
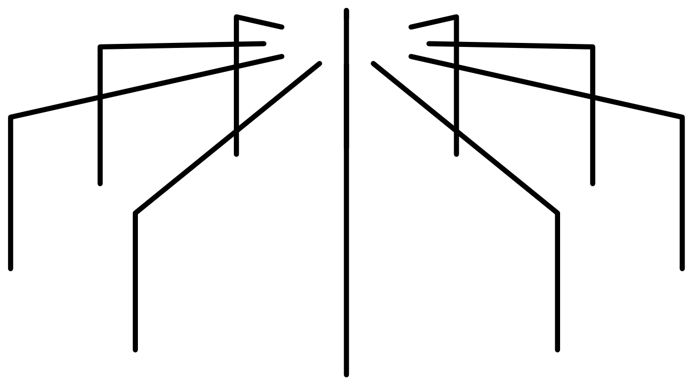
Introduction.



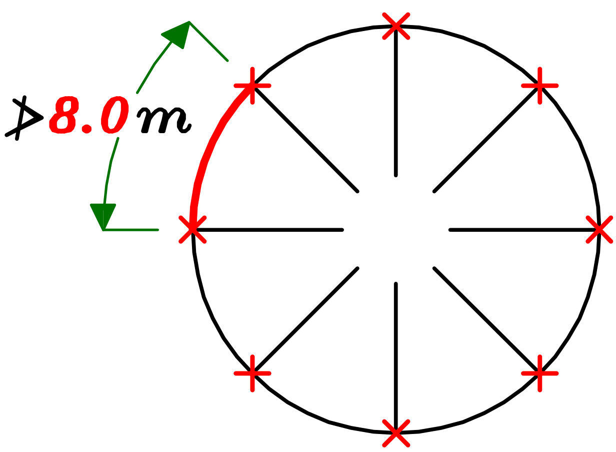
عاده نستخدم **Radial Frame**
عندما يكون شكل المبنى المراد تغطيته دائرى
و نختار له **span** تساوى $\boxed{L = r_3 - r_1}$
حيث r_3 هى نصف القطر الكلى للمبنى .
و r_1 هى نصف قطر الشخشيخه .



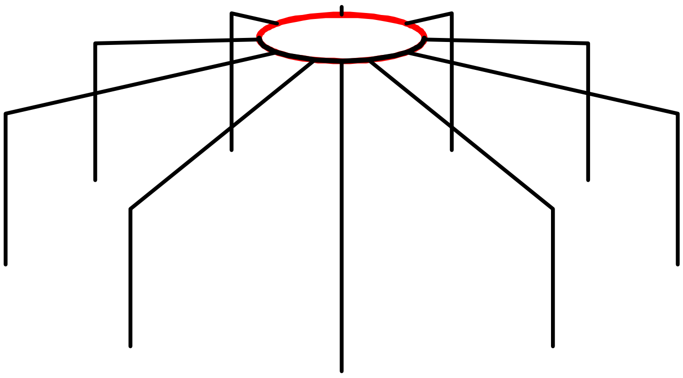
نضع **2 Radial Frames**
أمام بعض مباشره



ثم نكمل باقى ال **Frames**
بحيث سيكون عدد ال**Frames**
دائما رقم زوجى $\boxed{n = 6 \rightarrow 14}$



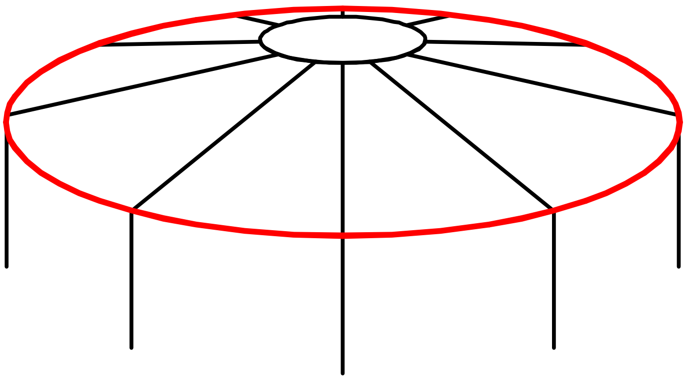
اذا لم يكن عدد ال **Frames** مُعطى
نحسبه من المعادله التاليه
تقرب لاقرب رقم زوجى بالزياده $\boxed{n = \frac{2 \pi r_3}{8}}$



نضع كمره دائريه Ring Beam داخليه

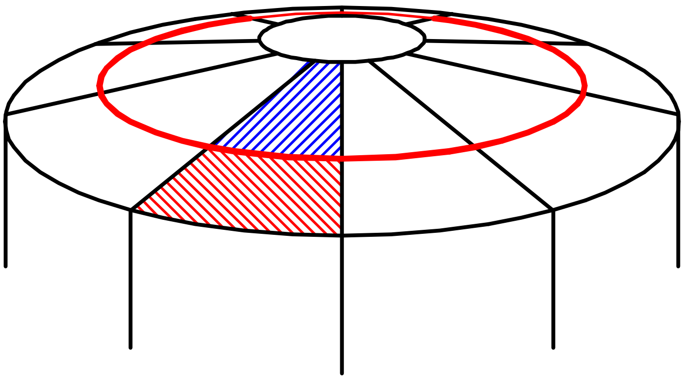
حتى تكون Stable Frames

و لربط ال Frames مع بعضها



نضع كمره دائريه Ring Beam خارجيه

لربط ال Frames مع بعضها



اذا كانت البلاطات Solid

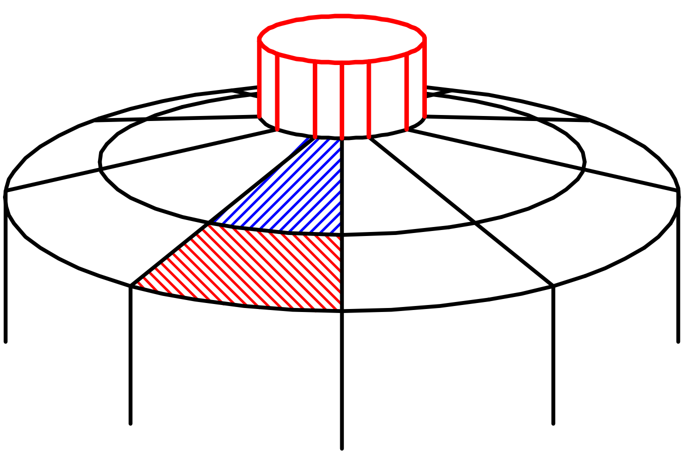
يفضل وضع كمرات دائريه فى الداخل

لتقليل مساحه البلاطات

يفضل وضع كمره عند $\frac{1}{3}$ ال span حتى
يكون للبلاطات المقسمه تقريبا نفس المساحه

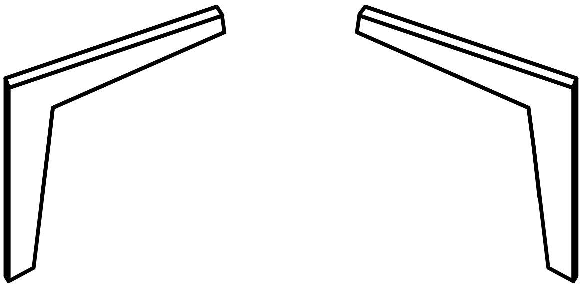
اذا كانت البلاطات Hollow Blocks

لا داعى لوضع كمرات داخليه

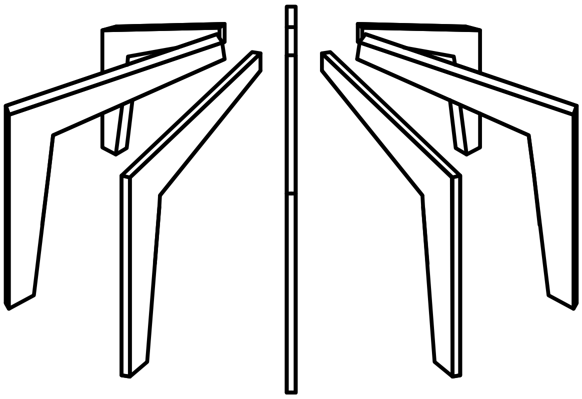


نضع posts على ال Frames

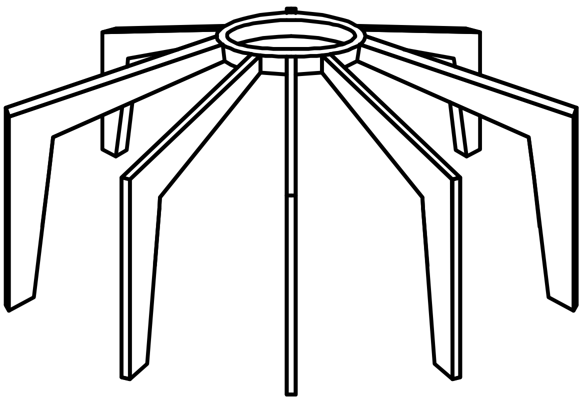
ثم نضع Ring Beam فوق ال posts



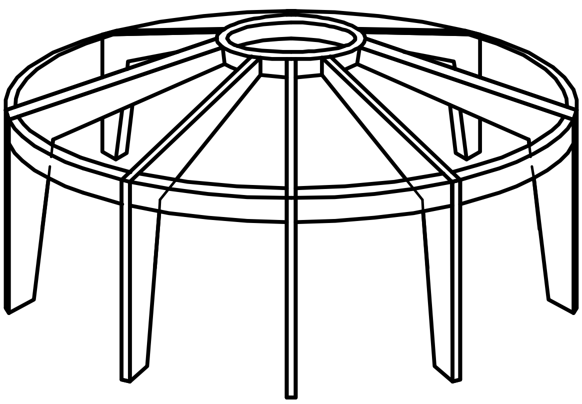
نضع **2 Radial Frames**
أمام بعض مباشره



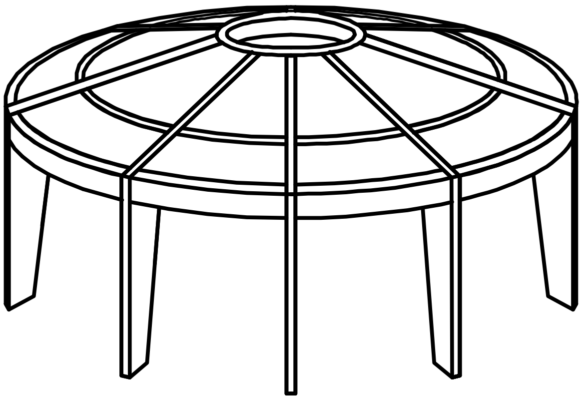
ثم نكمل باقى ال **Frames**



نضع كمره دائريه **Ring Beam** داخليه



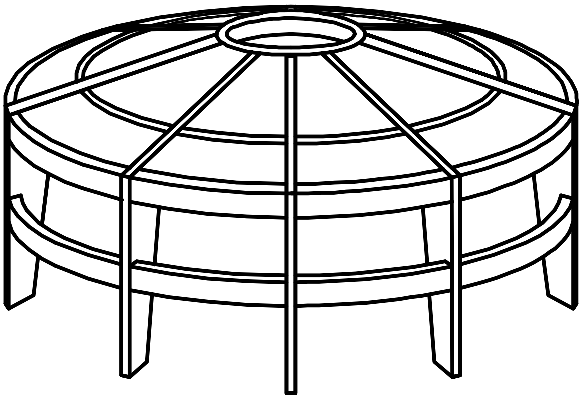
نضع كمره دائريه **Ring Beam** خارجيه



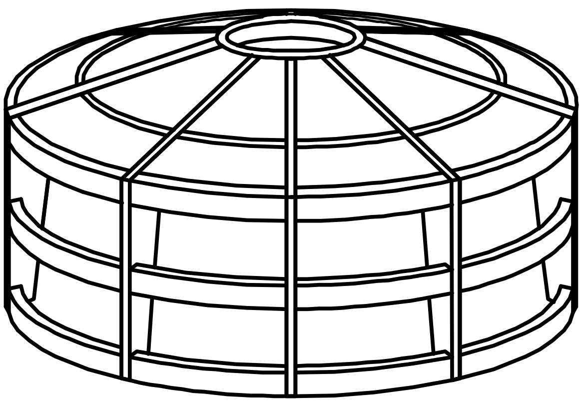
اذا كانت البلاطات *Solid*

يفضل وضع كمرات دائريه فى الداخل

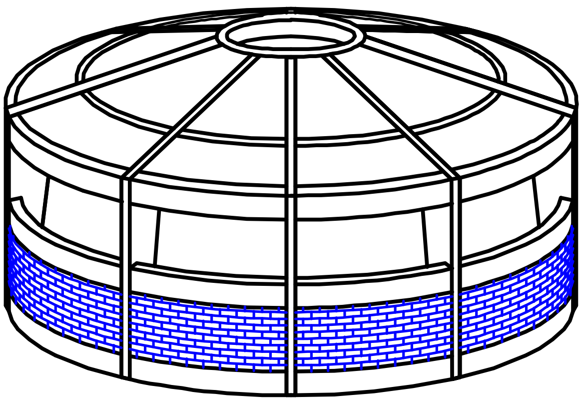
يفضل وضع كمره عند $\frac{١}{٣}$ ال *span*



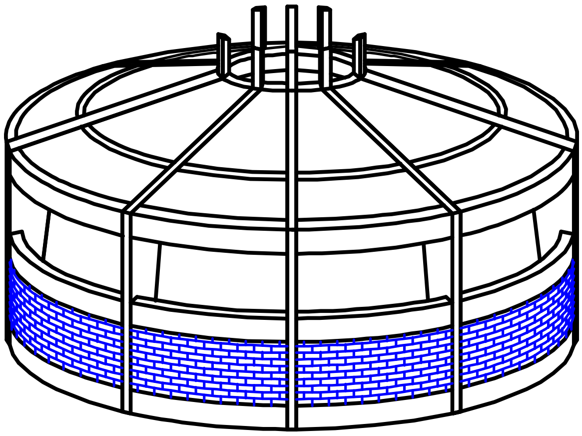
نضع كمرات دائريه تحت الشباك مباشره



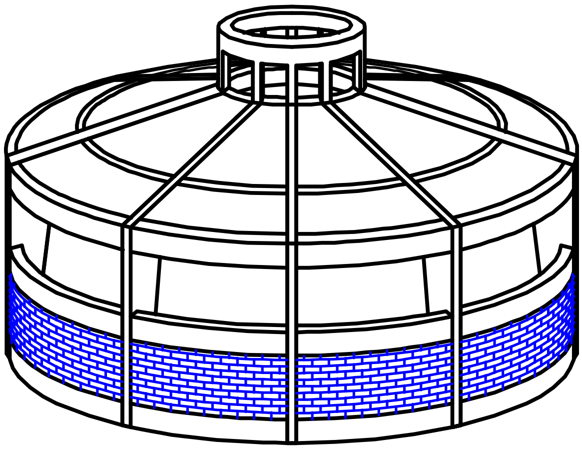
نضع سملات دائريه



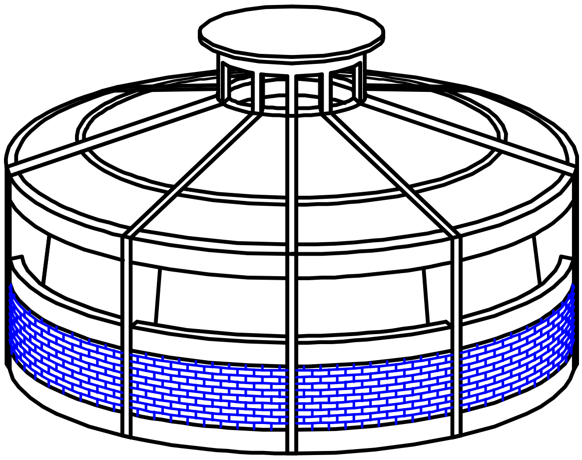
نضع الحائط الخارجى فوق السملات



نضع ال Frames على ال posts

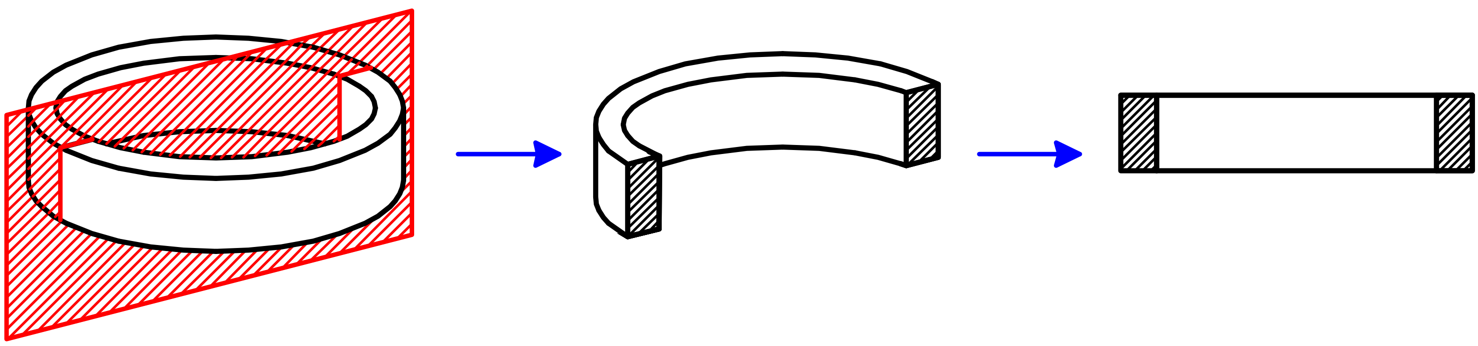


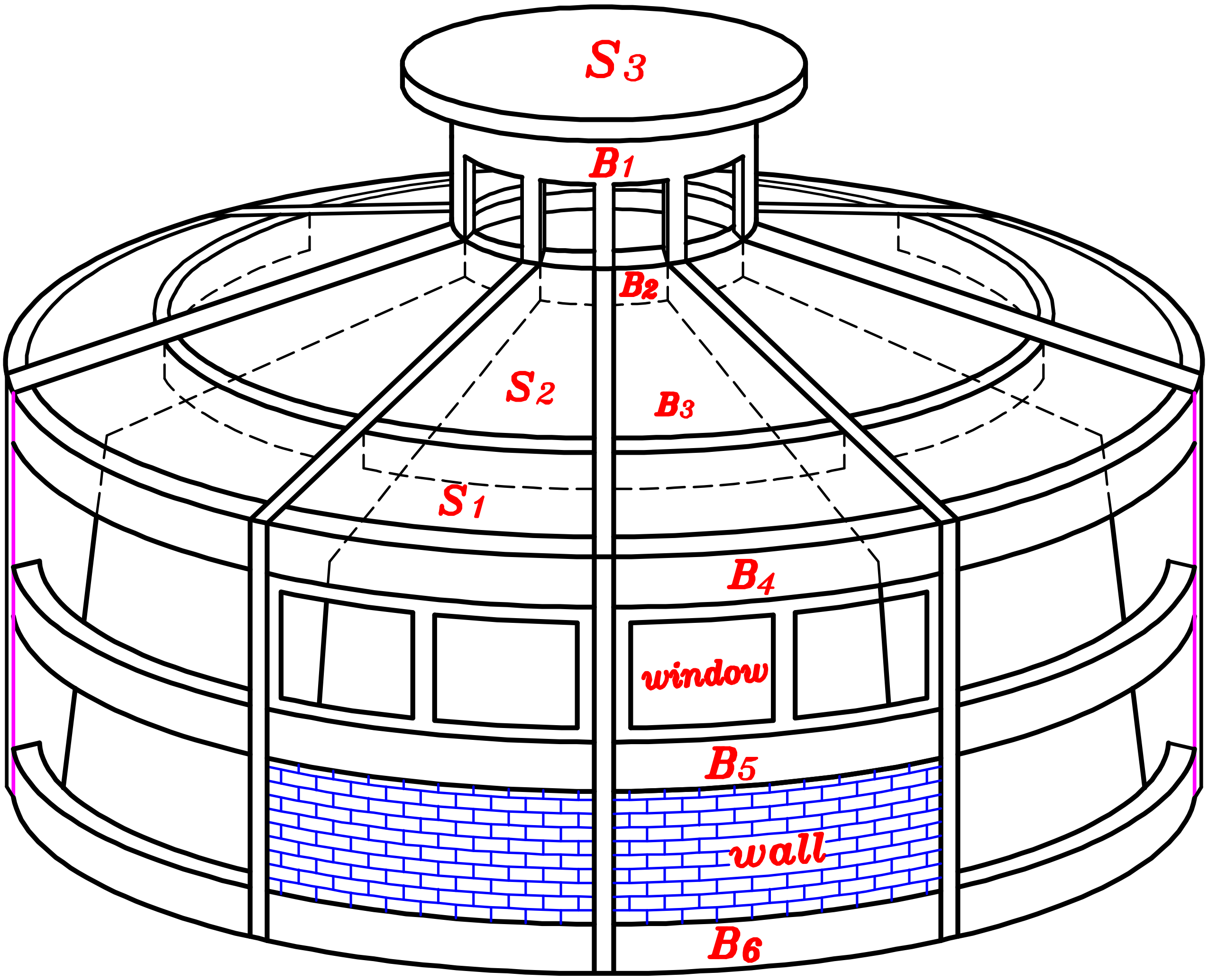
نضع Ring Beam فوق ال posts



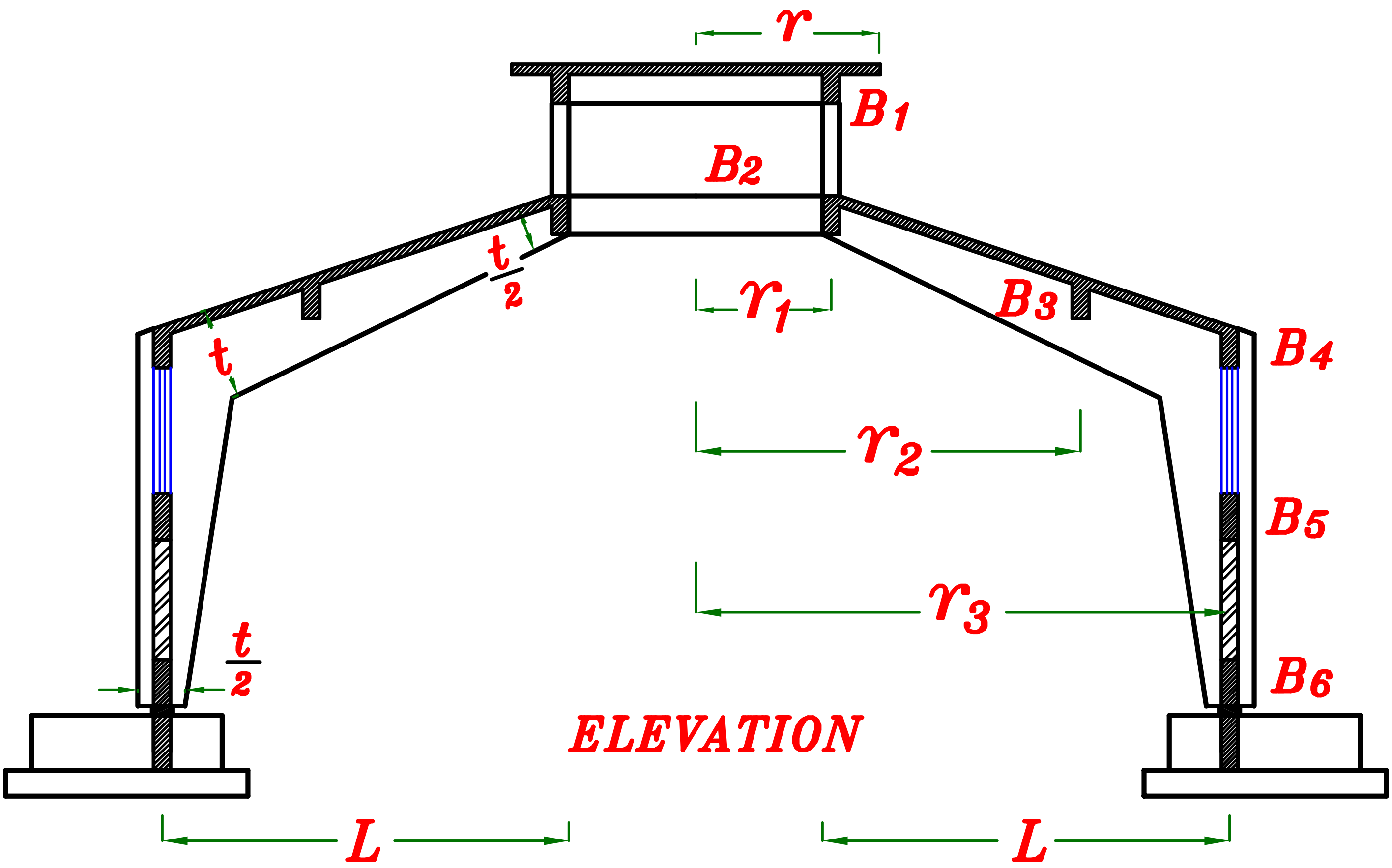
نضع بلاطه دائريه فوق ال Ring Beam

شكل ال Ring Beam عندما تقطع فى ال elevation





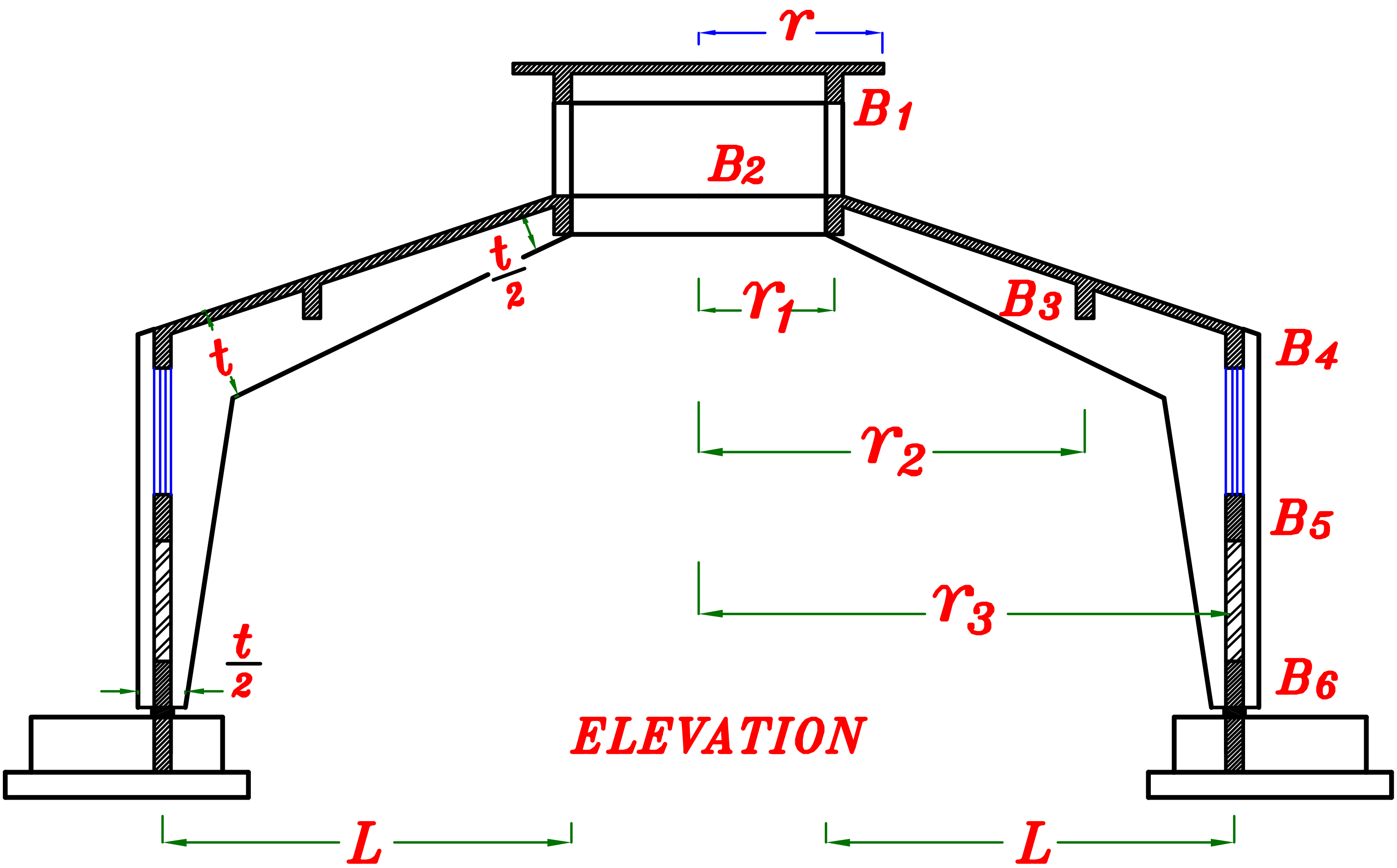
S3
B1
B2
S2
B3
S1
B4
window
B5
wall
B6



r
B1
B2
t/2
r1
B3
B4
t
r2
B5
r3
t/2
B6
L
L

ELEVATION

Concrete Dimensions.



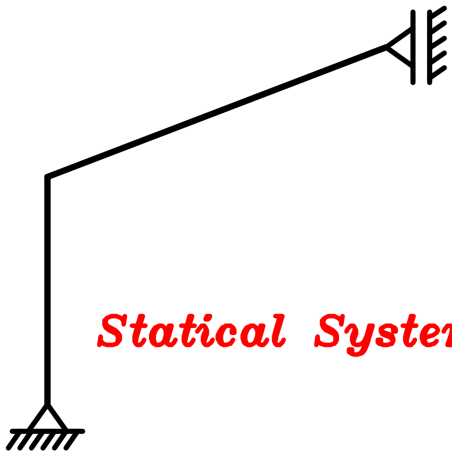
ELEVATION

* **Sky Light Radius** $(r_1) = (1 \longrightarrow 3)\ m$

* **Span** $(L) = r_3 - r_1 = (6 \longrightarrow 12)\ m$

* $t \simeq \dfrac{L}{(6 \rightarrow 8)}$

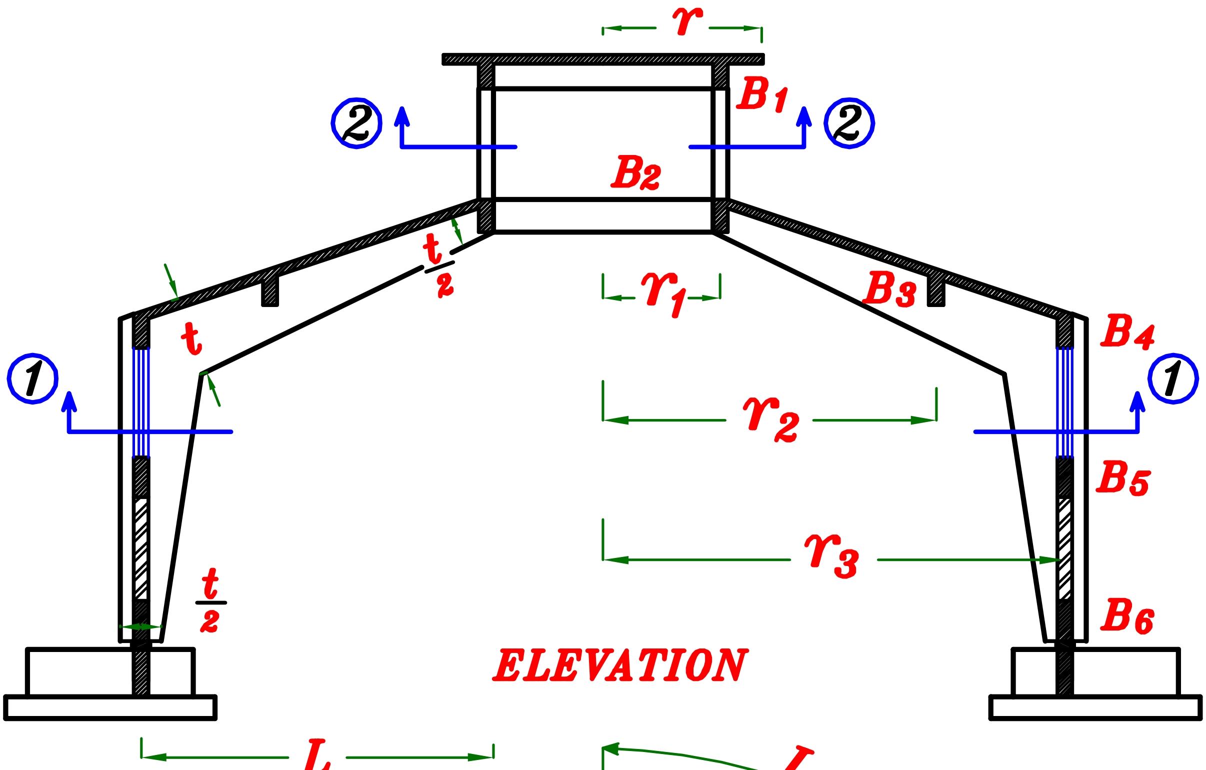
* $b = \left.\begin{matrix} 0.30\,m \\ \dfrac{L_3}{20} \end{matrix}\right\}$ الأكبر



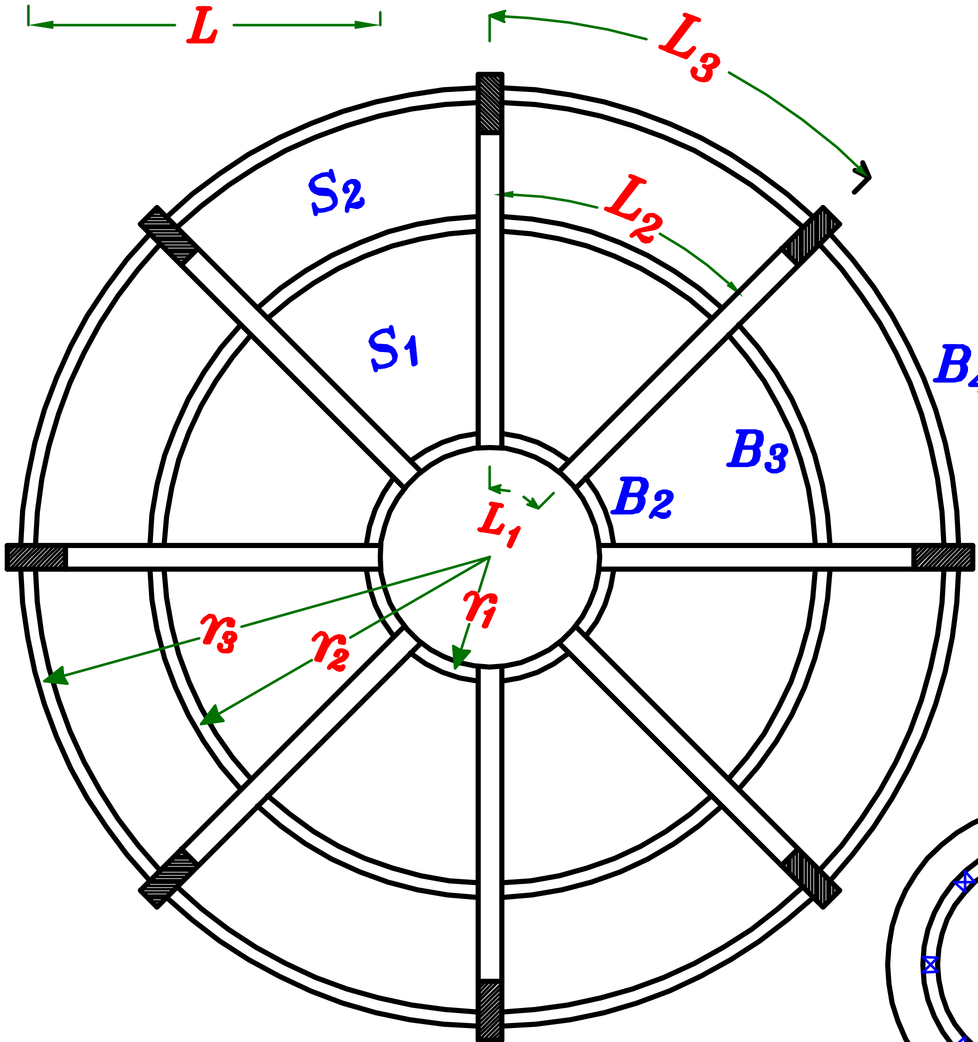
Statical System

* n = **No. of Frames** $\boxed{n = \dfrac{2\pi r_3}{8}}$ تقرب لاقرب رقم زوجى بالزياده

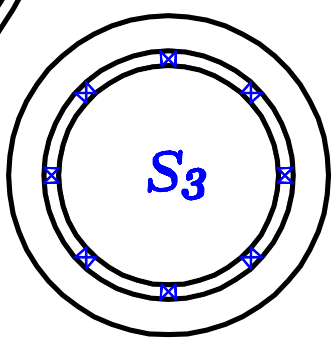
$= (6 - 8 - 10 - 12 - 14)$



ELEVATION



PLAN ①



PLAN ②

$$L_1 = \frac{2\pi r_1}{n} \quad , \quad L_2 = \frac{2\pi r_2}{n} \quad , \quad L_3 = \frac{2\pi r_3}{n}$$

Steps of Design.

١- يتم رسم قطاع واحد Sector فى البلاطات و تحديد اطوال بحور الكمرات و الاطوال المتوسطه للبلاطات .

٢- يتم فرض ان البلاطات شكلها مستطيل بالابعاد المتوسطه
و تحديد اذا كانت One way or Two way

٣- يتم حساب t_s لكل بلاطه و أخذ القيمه الاكبر لتكون t_s لكل البلاطات .

٤- يتم حساب w_s بناء على قيمه t_s المختاره

٥- يتم أخذ شرائح للبلاطات و تصميمها و رسم تسليحها فى ال Plan

٦- يتم فرض ابعاد للكمرات بناء على اطوال ال span و يتم حساب o.w. لكل كمره .

٧- يتم عمل Load distribution لاحمال البلاطات على الكمرات الدائريه و ال Frame
ثم حساب Reactions الكمرات على ال Frame .

٨- نضع احمال البلاطات و Reactions الكمرات على ال Frame
و يتم رسم S.F.D. & N.F.D. , B.M.D. لل Frame

٩- يتم تصميم ال Frame و رسم تسليحه فى ال Elevation

١٠- يتم حساب ال Bending و ال Shear و ال Torsion للكمرات الدائريه (المطلوبه فقط)
عن طريق الجداول .

١١- يتم تصميم الكمرات على ال Bending و الكانات على ال Shear و ال Torsion .
و رسم تسليح الكمرات فى ال Cross Section و رسمها فى ال Elevation اذا طُلب.

Design of Slabs.

اذا تم اختيار البلاطات **Solid Slabs**

يتم رسم قطاع واحد **Sector** فى البلاطات و حساب الاطوال .

$$- L_1 = \frac{2\pi r_1}{n}$$

$$L_2 = \frac{2\pi r_2}{n}$$

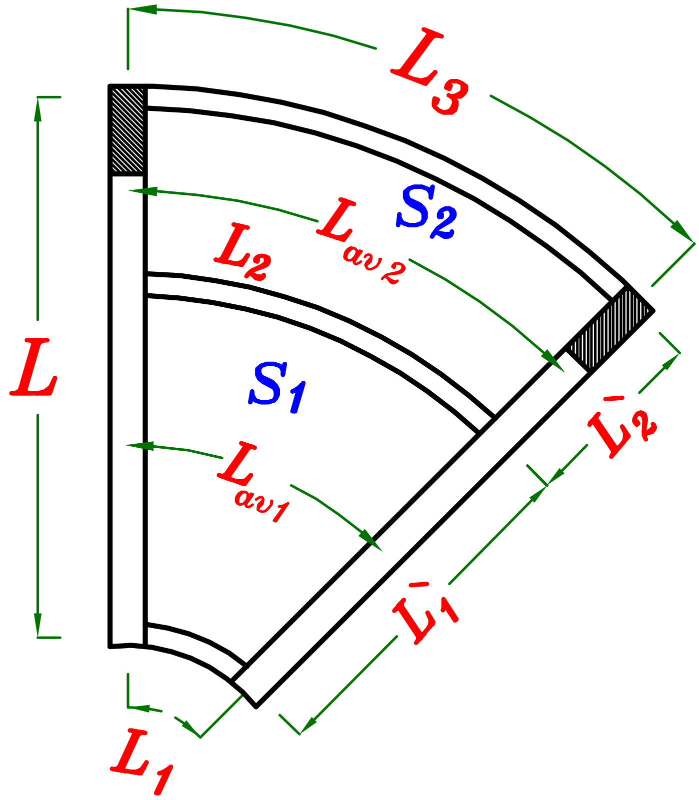
$$L_3 = \frac{2\pi r_3}{n}$$

$$- L_{av1} = \frac{L_1 + L_2}{2}$$

$$L_{av2} = \frac{L_2 + L_3}{2}$$

$$- L_1^{`} \simeq \frac{2}{3} L$$

$$L_2^{`} = L - L_1^{`}$$

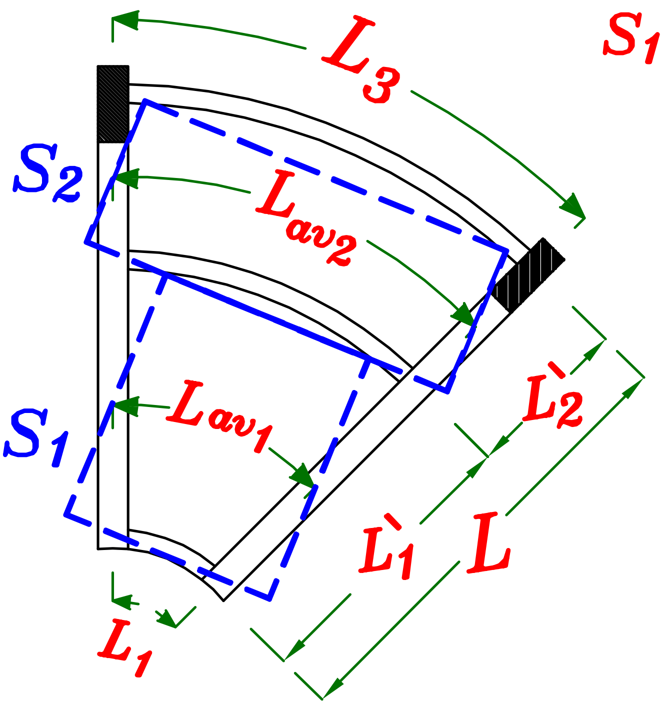


يتم حساب r لكلا البلاطتين S_1 & S_2

على اساس انها بلاطات مستطيله

ابعادها $S_1 = (L_1^{`} * L_{av1})$

$S_2 = (L_2^{`} * L_{av2})$



For S_1

$$S_1 = (L_1' * L_{av1})$$

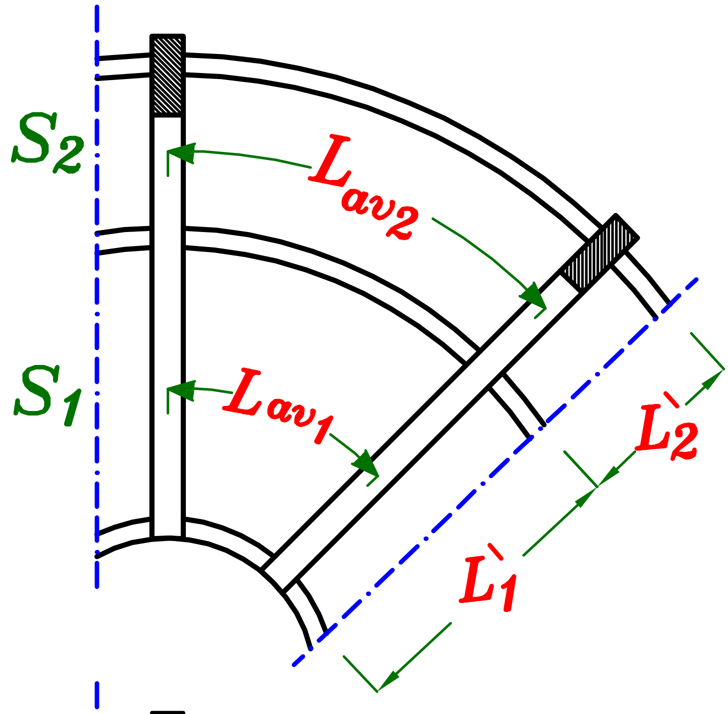
$$r = \frac{m\ L_1'}{m'\ L_{av.1}} = \frac{0.87\ L_1'}{0.76\ L_{av\ 1}}$$

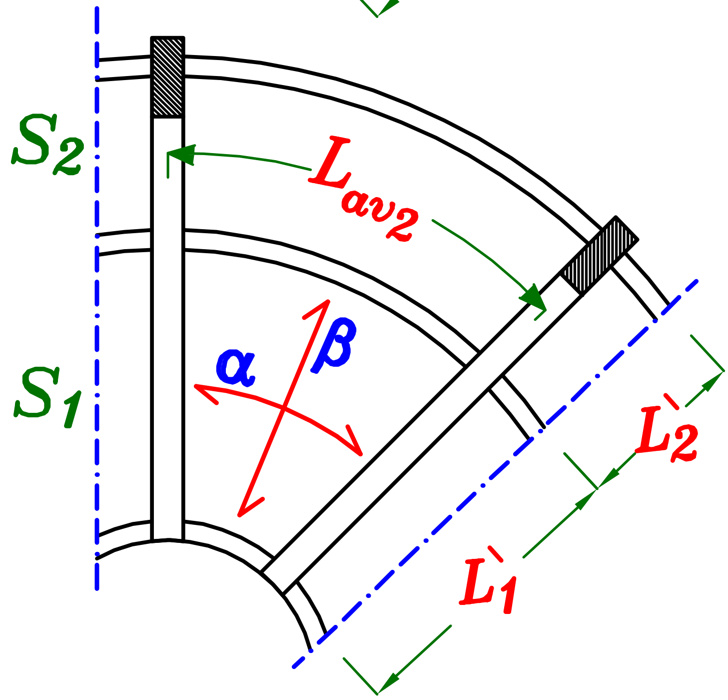
$r \leqslant 2.0 \longrightarrow$ Two way

$$t_{s1} = \frac{L_{av1}}{45}$$

$$\boxed{\alpha = 0.5\, r - 0.15}$$

$$\boxed{\beta = \frac{0.35}{r^2}}$$





For S_2

$$S_2 = (L_2' * L_{av2})$$

$$r = \frac{m * L_{av\ 2}}{m' * L_2'} = \frac{0.76\ L_{av\ 2}}{0.87\ L_2'}$$

IF $r > 2.0 \longrightarrow$ One way $\longrightarrow t_{s2} = \frac{L_2'}{30}$

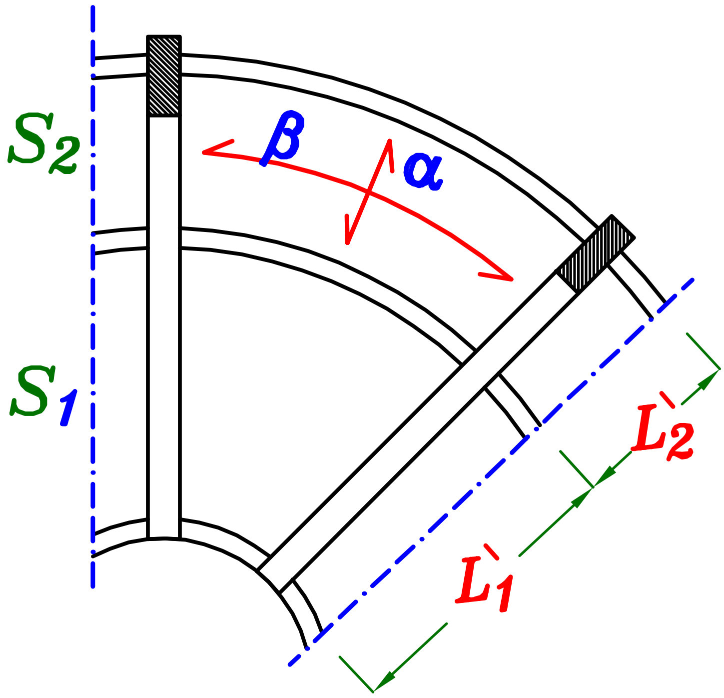
IF $r \leqslant 2.0 \longrightarrow$ Two way $\longrightarrow t_{s2} = \frac{L_2'}{40}$

$$\boxed{\alpha = 0.5\, r - 0.15} \qquad \boxed{\beta = \frac{0.35}{r^2}}$$

IF S_2 is Two way.

$$\boxed{\alpha = 0.5\,r - 0.15}$$

$$\boxed{\beta = \frac{0.35}{r^2}}$$

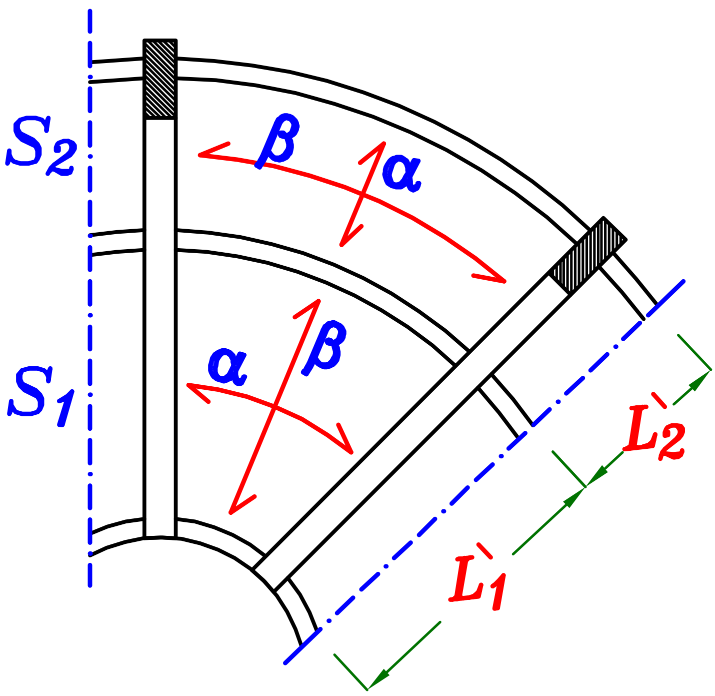


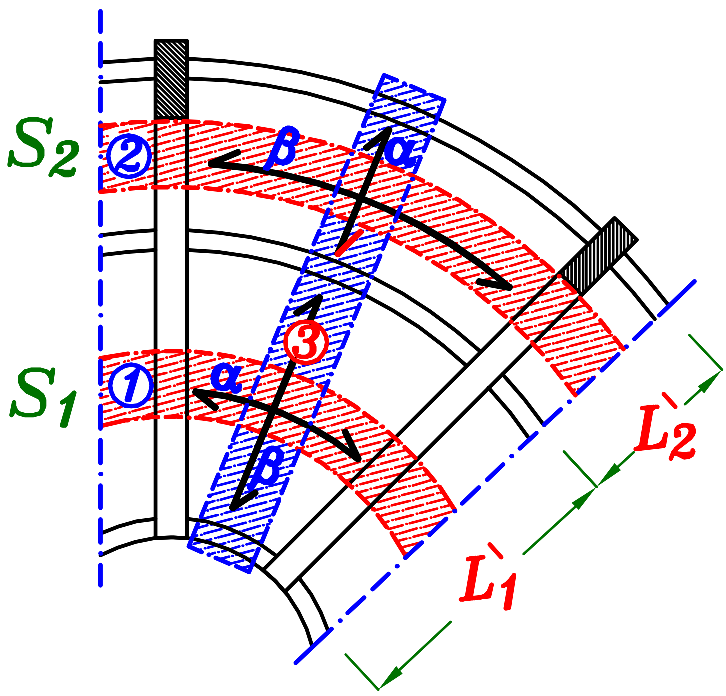
t_s is the bigger value of t_{s1} & t_{s2}

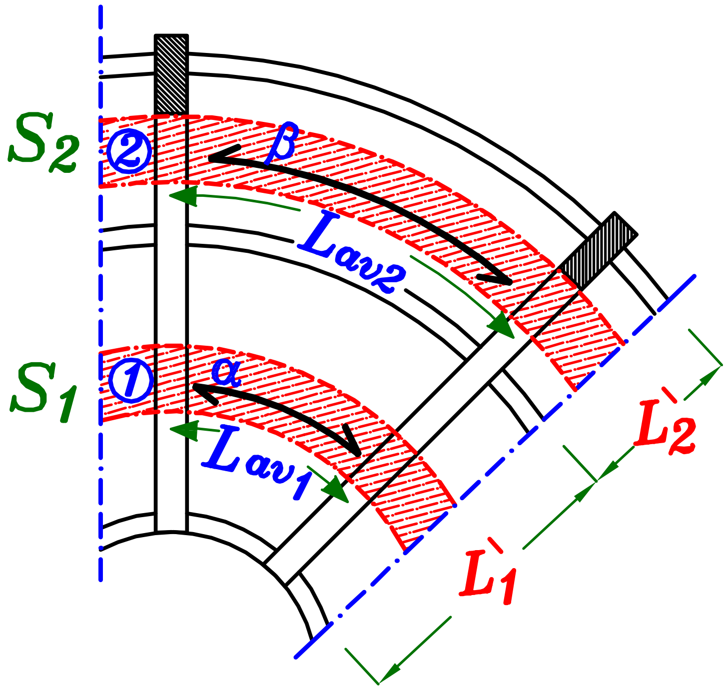
$$w_s = 1.4\,(t_s\,\gamma_c + F.C.) + 1.6\,(L.L.)\,\cos\theta$$

θ هى زاويه ميل البلاطه مع المستوى الافقى اذا كانت البلاطه مائله .

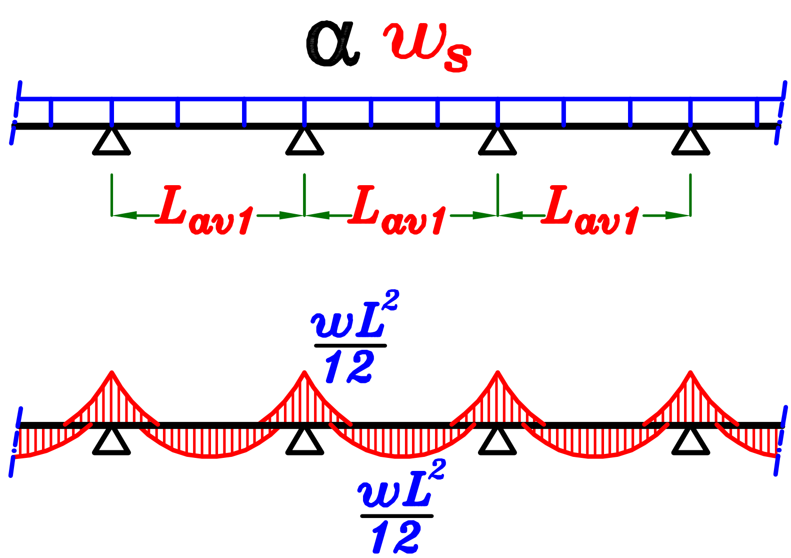
Take strips in the slabs.







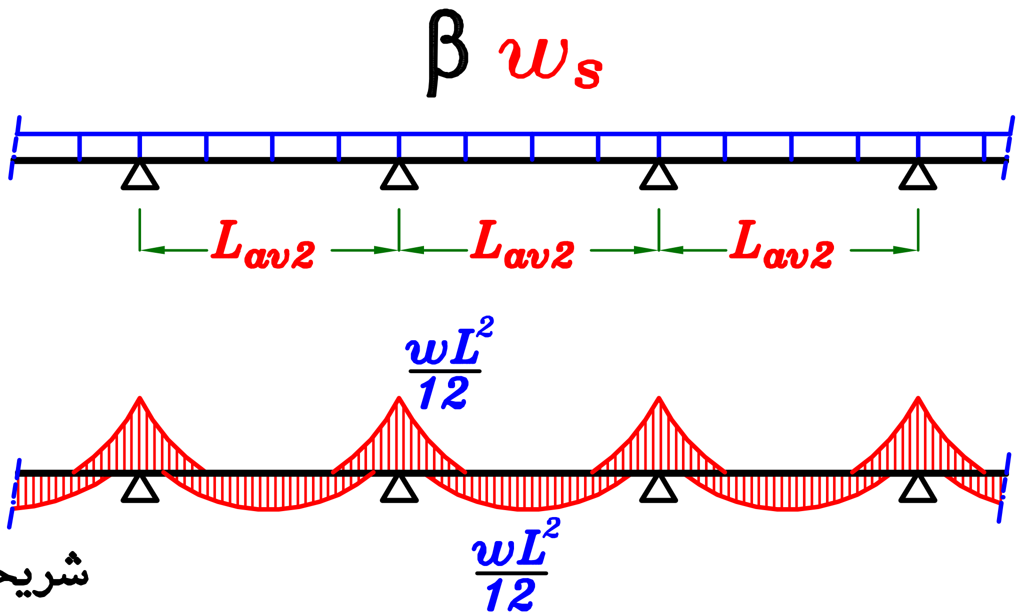
Strip ①



شريحه افقيه فى بلاطه مائله

$$M_{des.} = M \, Cos\,\theta$$

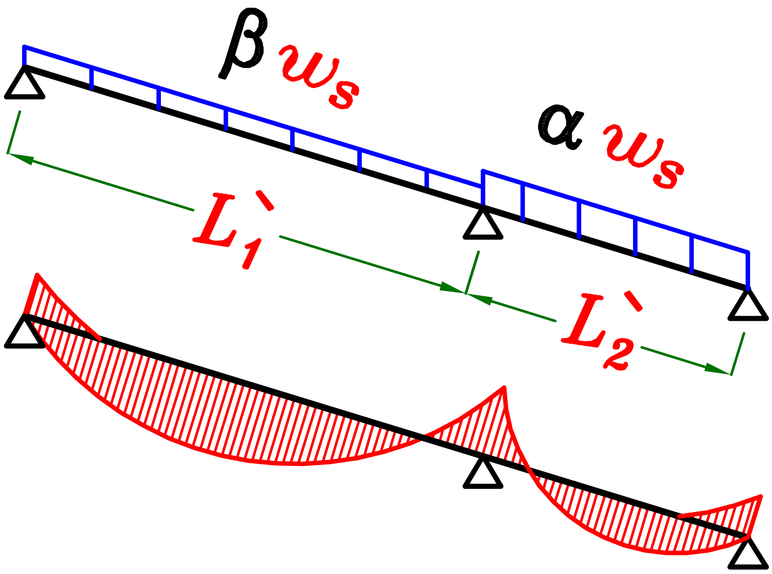
Strip ②

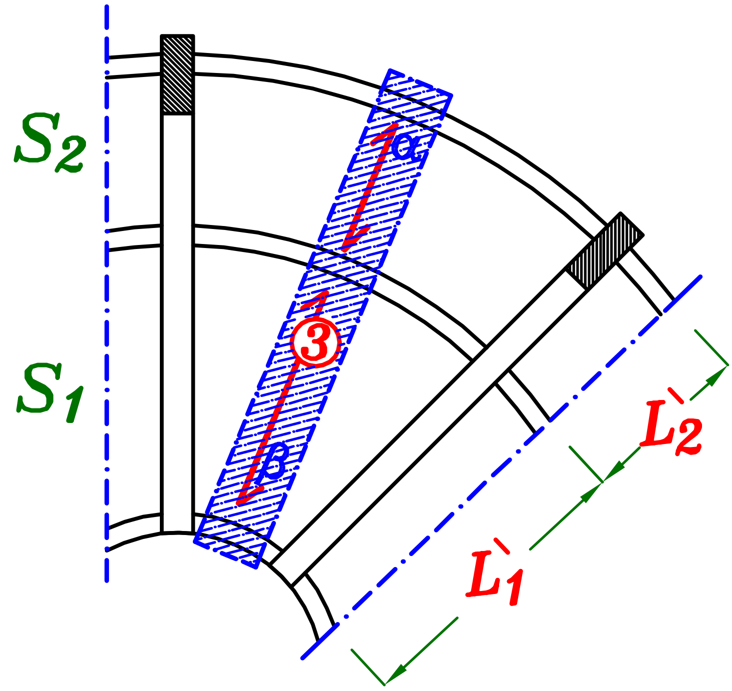


شريحه افقيه فى بلاطه مائله

$$M_{des.} = M \, Cos\,\theta$$

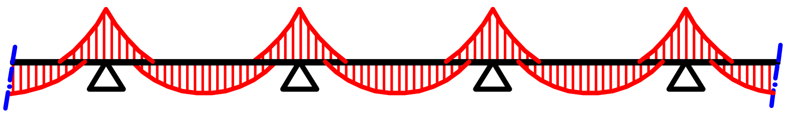
Strip ③

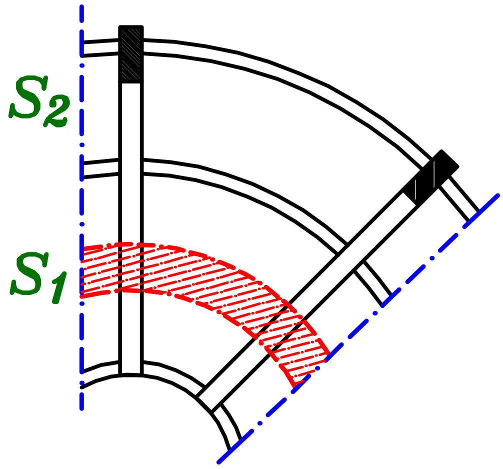


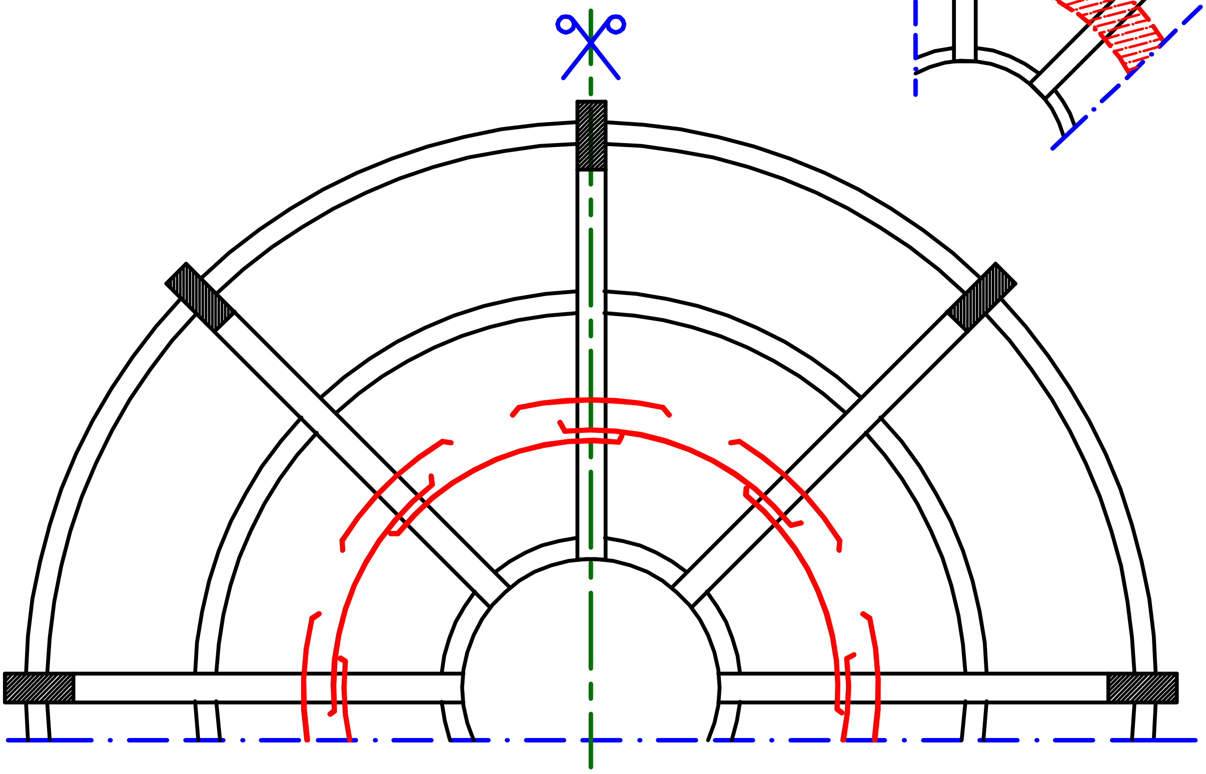


Draw RFT. of Slabs in Plan.

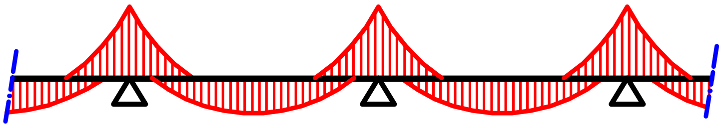
Strip ①

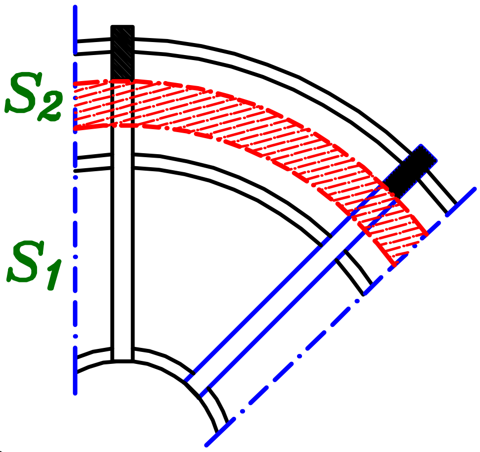


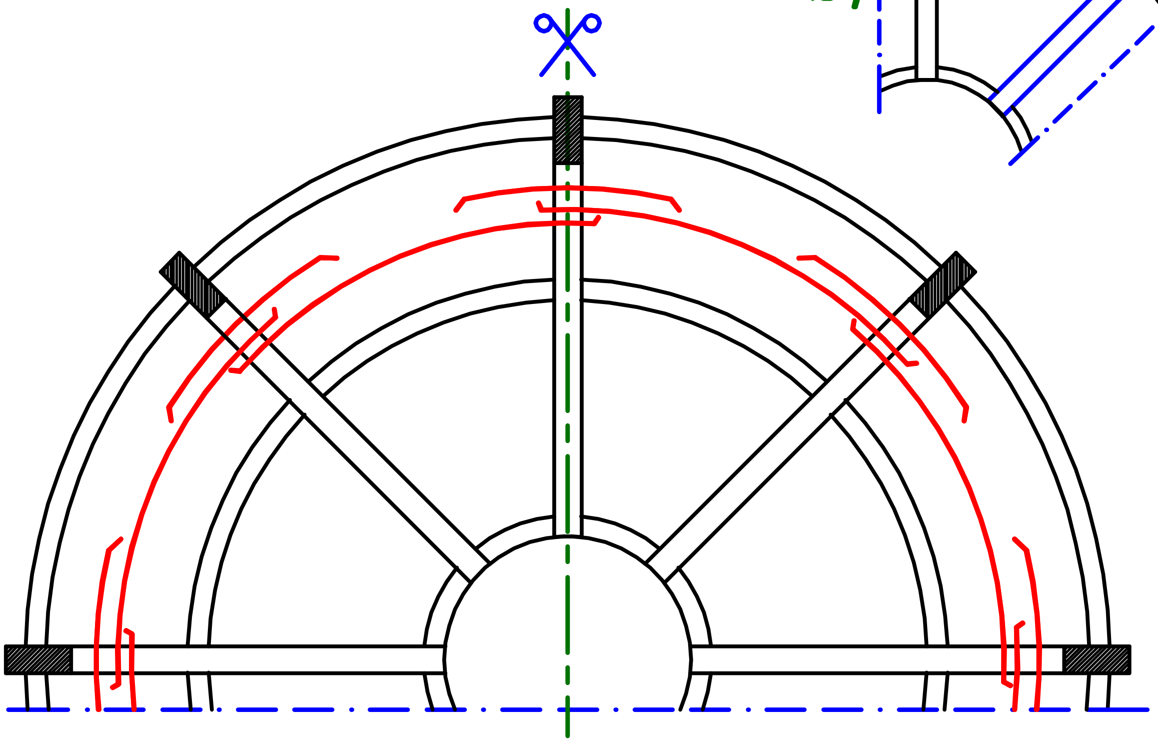




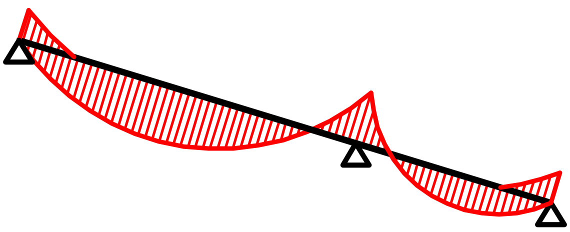
Strip ②

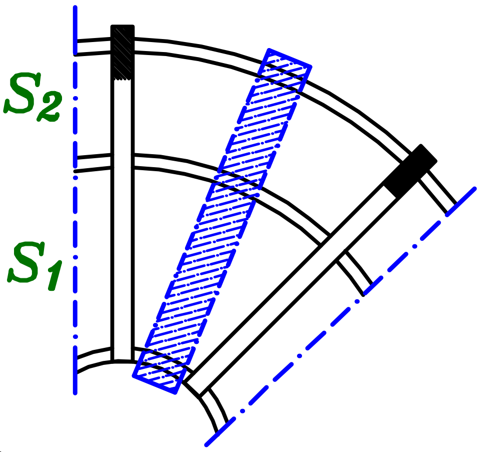


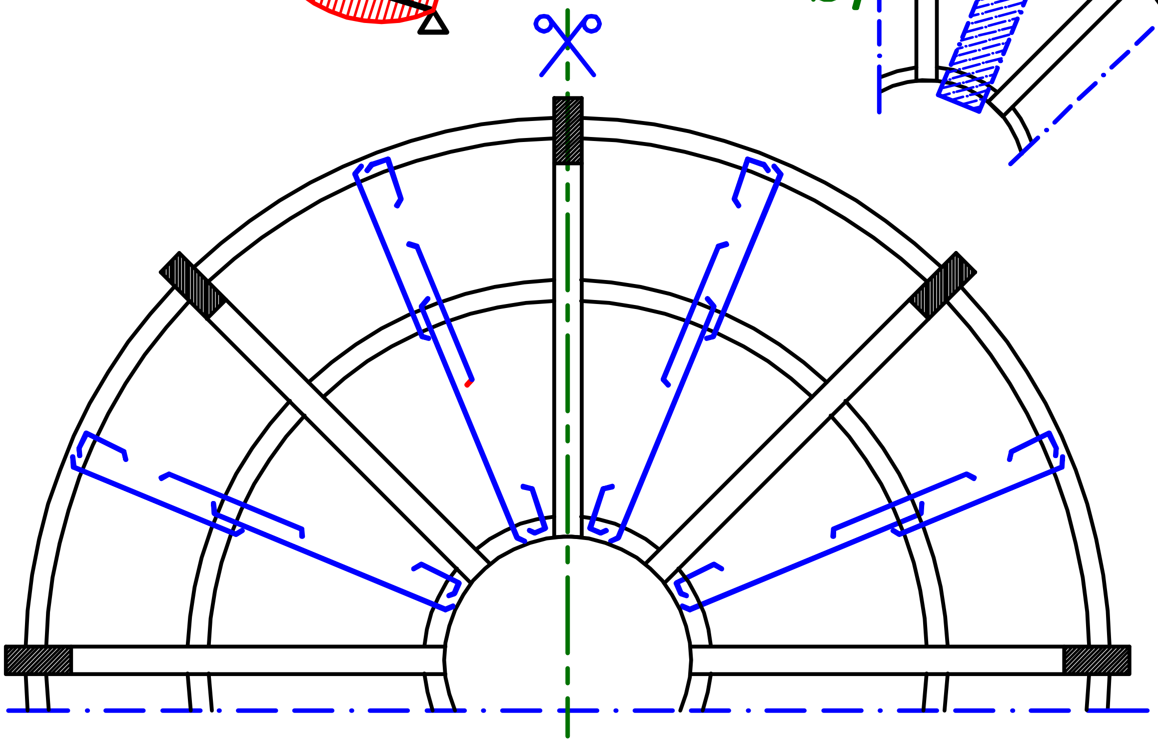


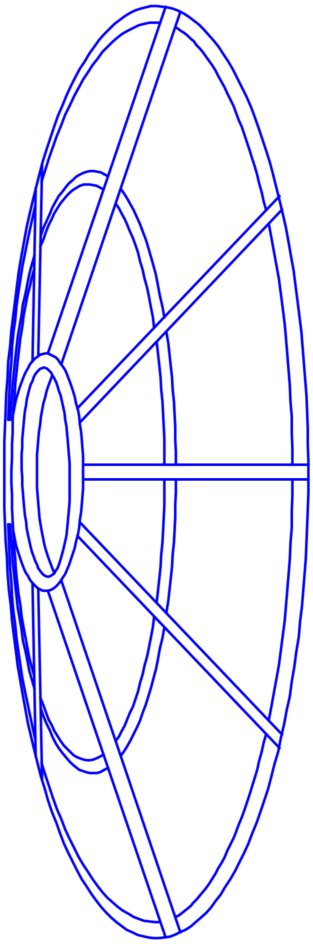


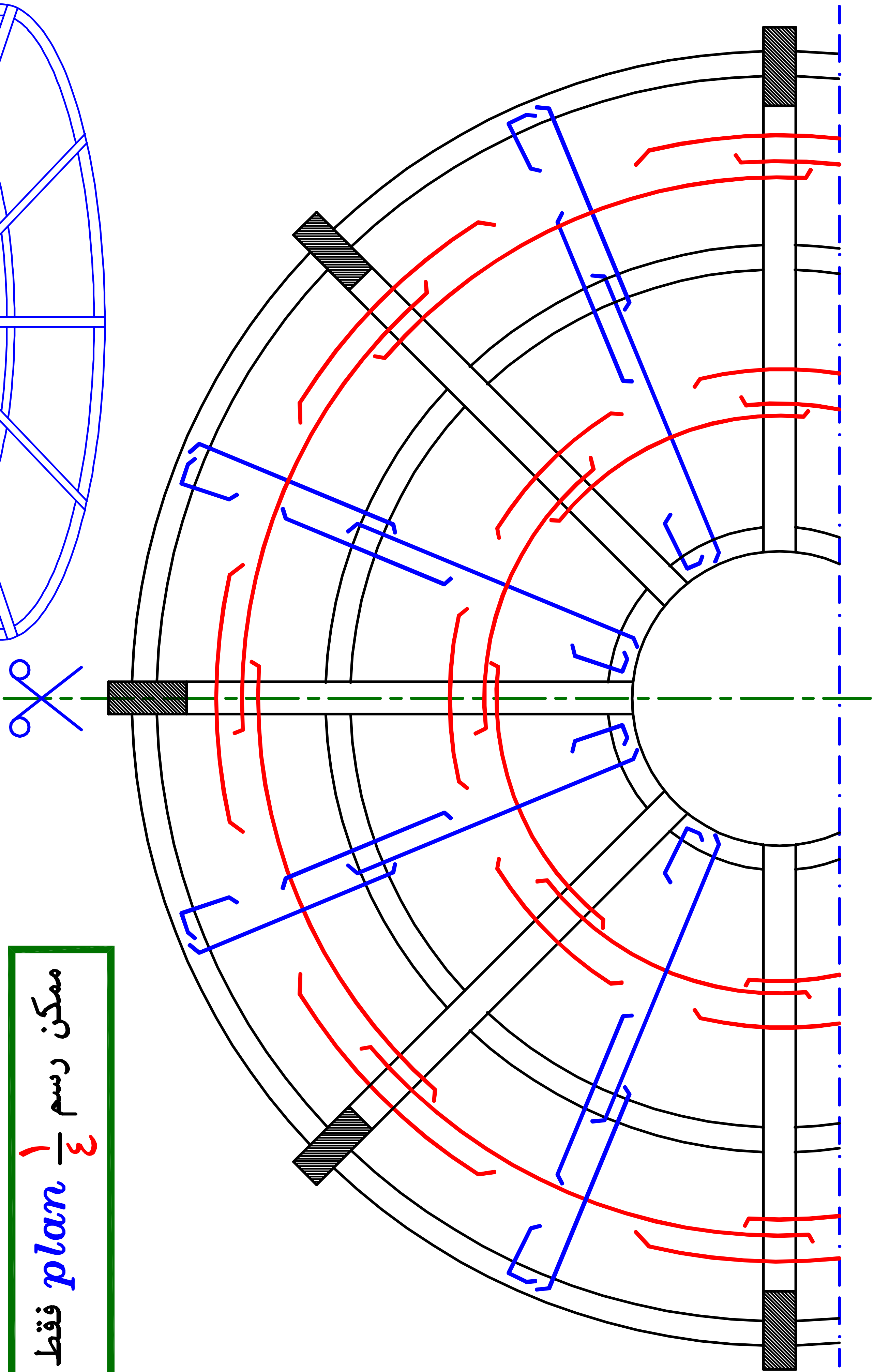
Strip ③











RFT. of the Slab.

Solid Slabs.

ممكن رسم $\frac{1}{٤}$ plan فقط

Load Distribution.

يتم عمل *Load distribution* لاحمال البلاطات على الكمرات الدائريه و ال *Frame*

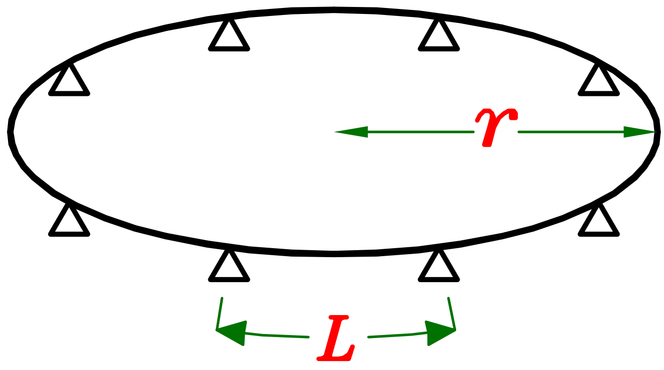
ثم حساب *Reactions* الكمرات على ال *Frame* .

Loads on Ring Beams.

لان ال *Ring beams* عباره عن كمرات *Continuous* و لكن يوجد عليها *Torsion*

لذا يفضل ان نعمل على زياده ابعاد قطاعها لتتحمل ال *Torsion*

Span $\boxed{L = \dfrac{2\pi r}{n}}$

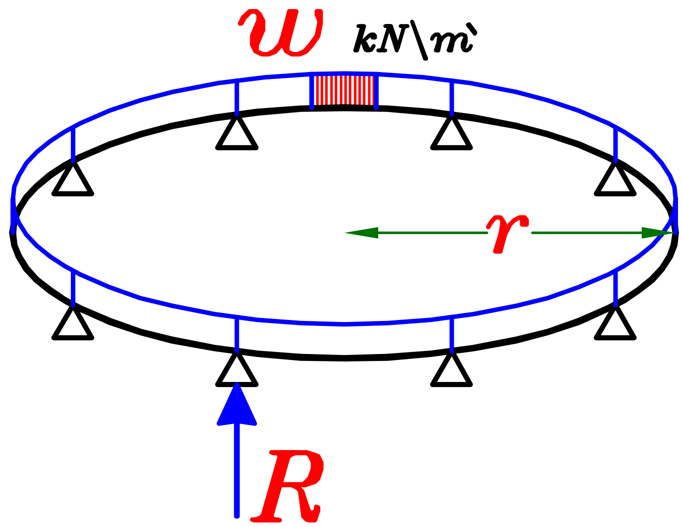


Take $\boxed{b = 0.25\ m \text{ or } 0.30\ m}$

Take $\boxed{t = \dfrac{L}{12} + 0.20\ m}$

$$o.w.(beam) = 1.4 * b * t * \gamma_c$$

To get the Reaction of Ring Beams.

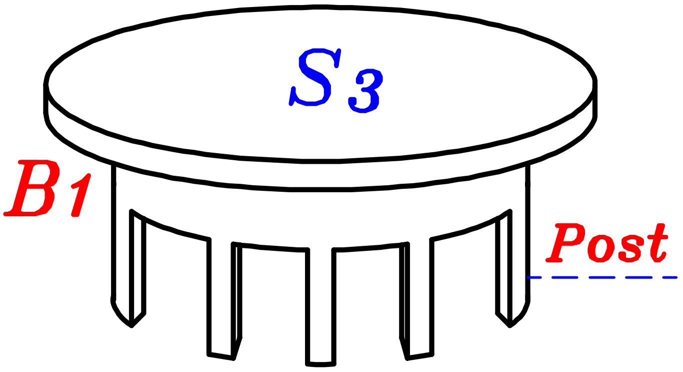


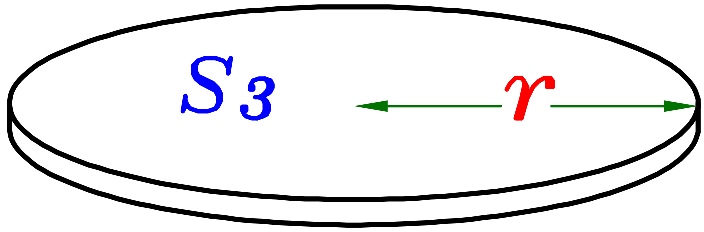
$$\boxed{R = \frac{\sum Weight}{number\ of\ Supports}}$$

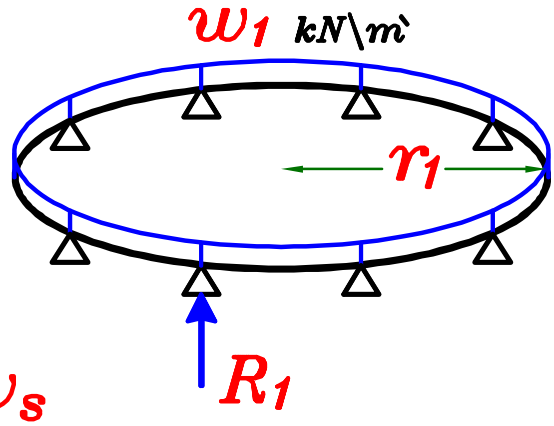
$$\boxed{R = \frac{w * 2\pi r}{n}}$$

① Upper Beam B_1

Sky Light







$$w_1 = o.w._{(beam)} + \frac{\sum Area}{Span} * w_s$$

$$w_1 = o.w._{(beam)} + \frac{\pi r^2}{2\pi r_1} * w_s$$

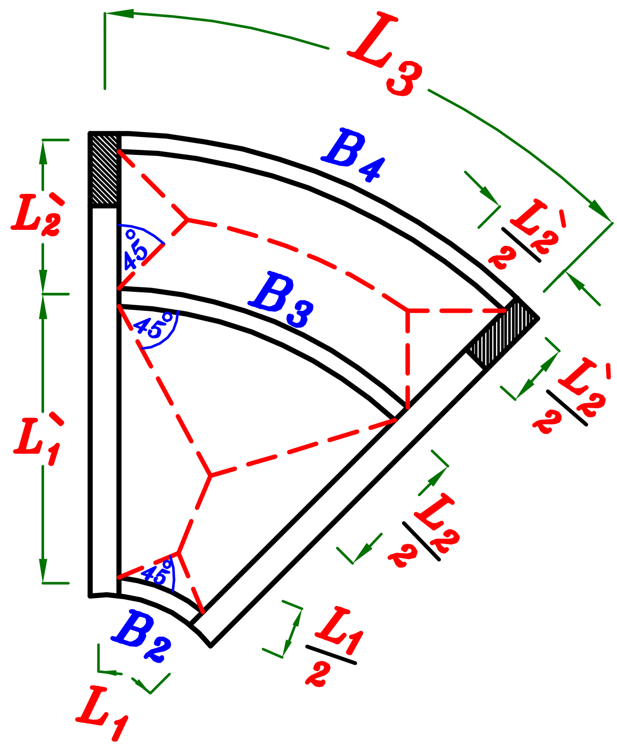
$$R_1 = \frac{w_1 * 2\pi r_1}{n}$$ n = number of supports

② Load of Post. $\simeq$ 3.50 kN\m` (U.L.)

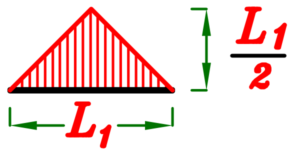
S_1, S_2 يتم توزيع الاحمال على البلاطات

يفضل توزيع الاحمال بزاويه 45° للتسهيل

بحيث سيكون الارتفاع يساوى نصف القاعده

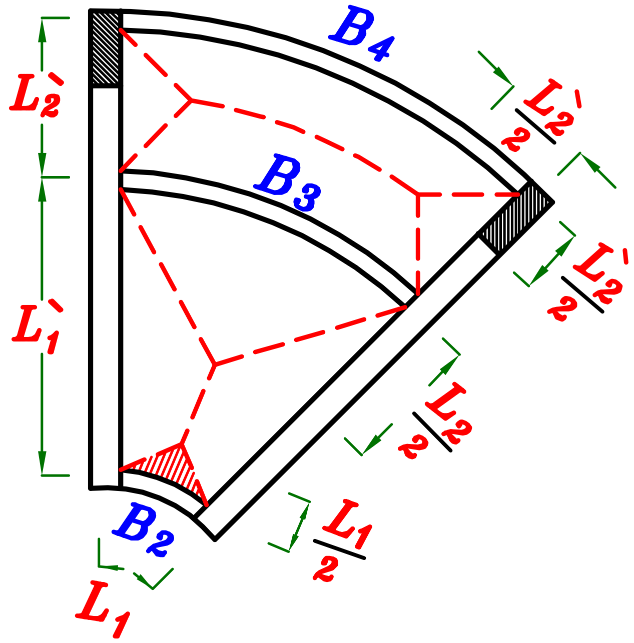


Loads on B_2



$$C_a = \frac{1}{2}$$

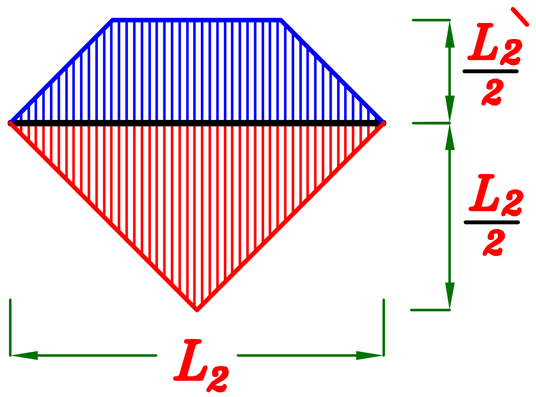
$$C_e = \frac{2}{3}$$

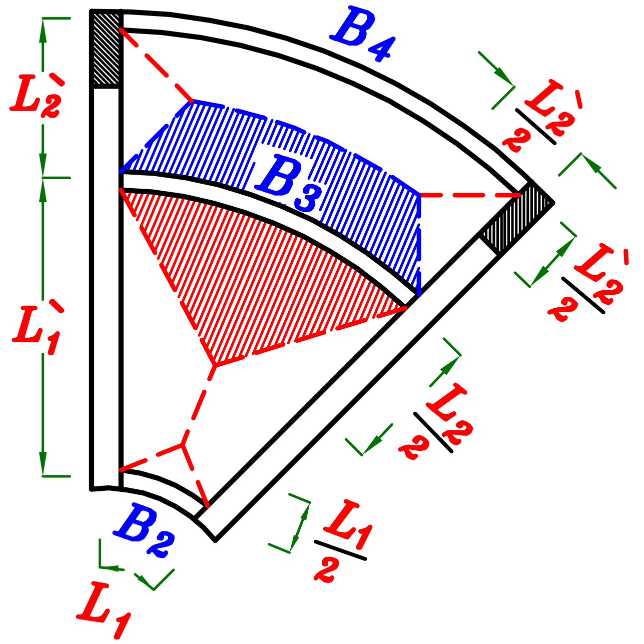


$$w_2 = o.w.(beam) + C_a w_s \frac{L_1}{2}$$

$$R_2 = \frac{w_2 * 2\pi r_1}{n}$$

Loads on B_3





For Triangle $C_a = \frac{1}{2}$, $C_e = \frac{2}{3}$

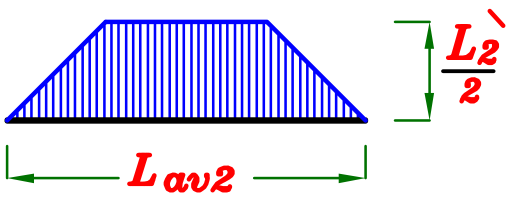
For Trapezium $C_a = 1 - \frac{1}{2}\left(\frac{L_2^{`}}{L_{av2}}\right)$

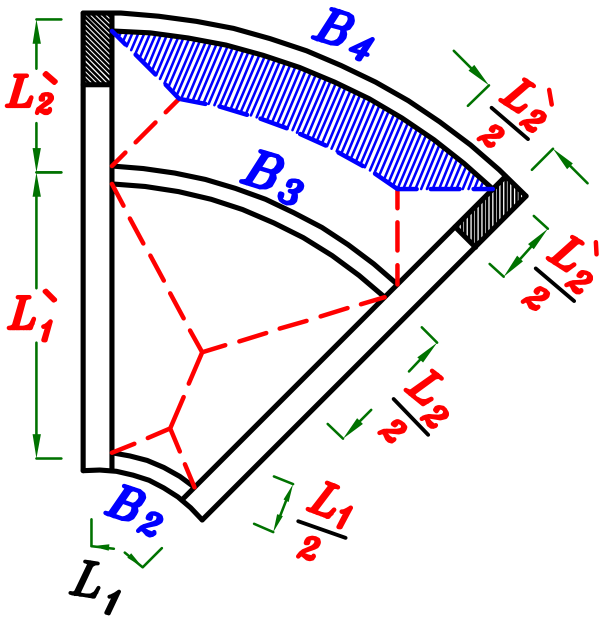
$$C_e = 1 - \frac{1}{3}\left(\frac{L_2^{`}}{L_{av2}}\right)^2$$

$$w_3 = o.w.(beam) + C_a w_s \frac{L_2}{2} + C_a w_s \frac{L_2^{`}}{2}$$

$$R_3 = \frac{w_3 * 2\pi r_2}{n}$$

Loads on B_4

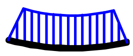




For Trapezium

$$C_a = 1 - \frac{1}{2}\left(\frac{L_2'}{L_{av2}}\right)$$

$$C_e = 1 - \frac{1}{3}\left(\frac{L_2'}{L_{av2}}\right)^2$$

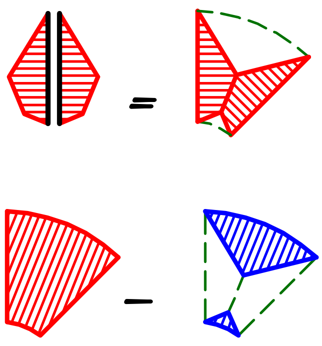


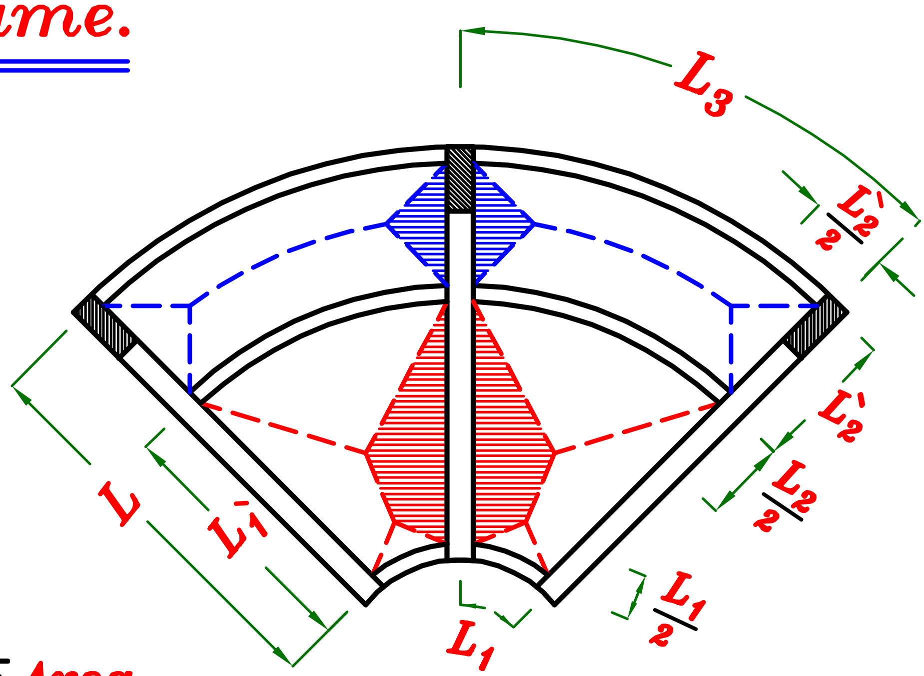
$$w_4 = o.w._{(beam)} + C_a\, w_s\, \frac{L_2'}{2}$$

$$R_4 = \frac{w_4 * 2\pi r_3}{n}$$

Loads on Frame.

$\Sigma Area =$

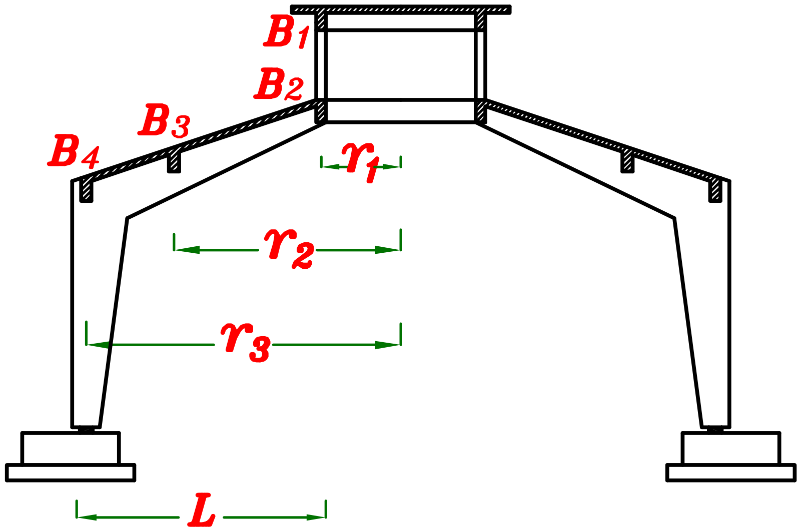




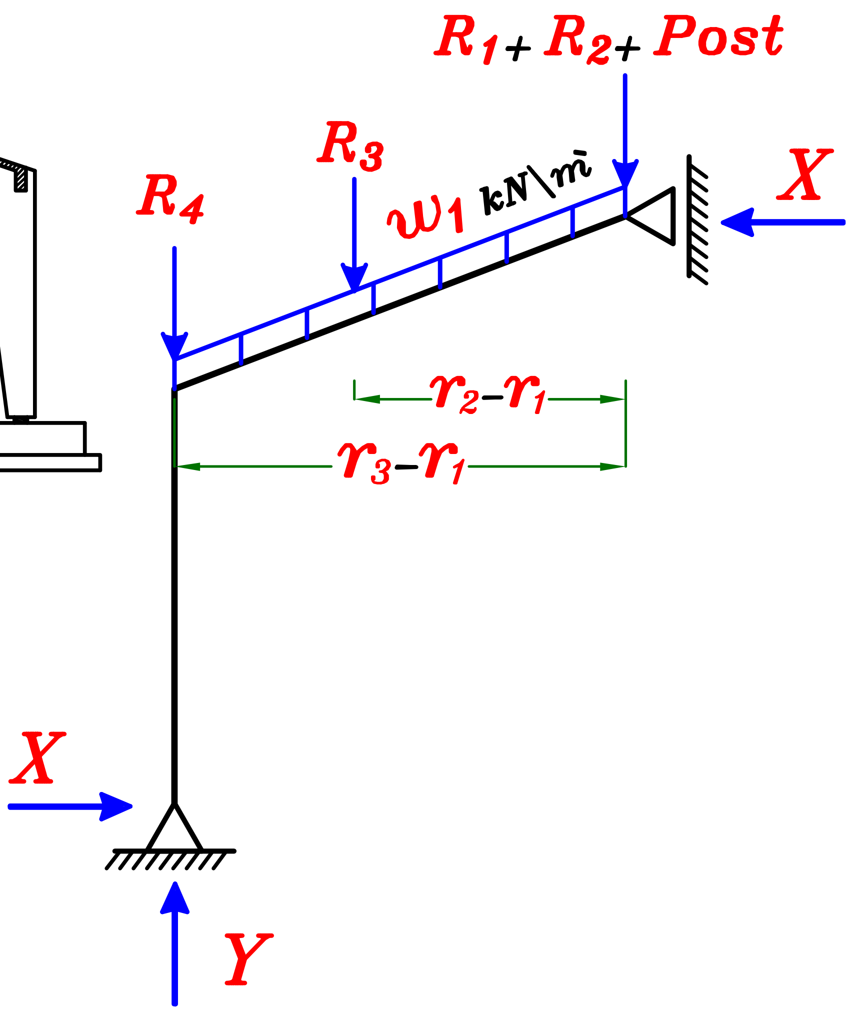
$$w_1 = o.w._{(Frame)} + \frac{\Sigma Area}{Span} * w_s$$

$$\Sigma Area = \left(\frac{L_1 + L_2}{2} * L_1' - \frac{1}{2} L_1 \frac{L_1}{2} - \frac{1}{2} L_2 \frac{L_2}{2}\right) + 2\left[\frac{1}{2} L_2' \frac{L_2'}{2}\right]$$

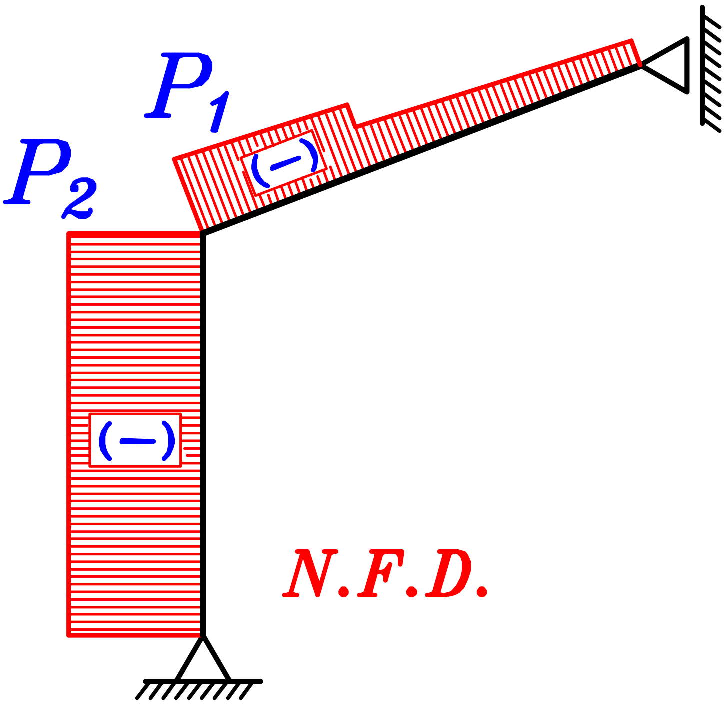
$$Span = L$$



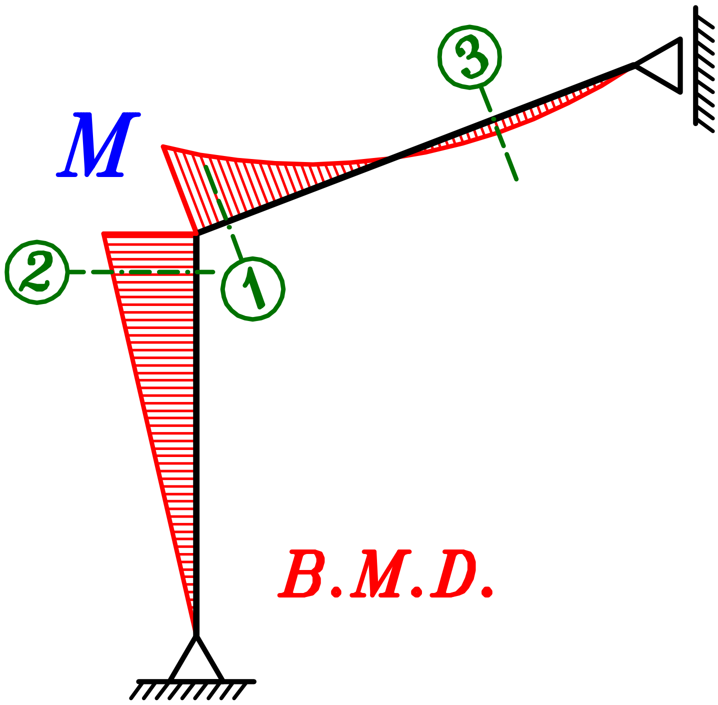
B1
B2
B3
B4
r1
r2
r3
L



R1+ R2+ Post
R3
R4
w1 kN\m'
X
r2-r1
r3-r1
X
Y

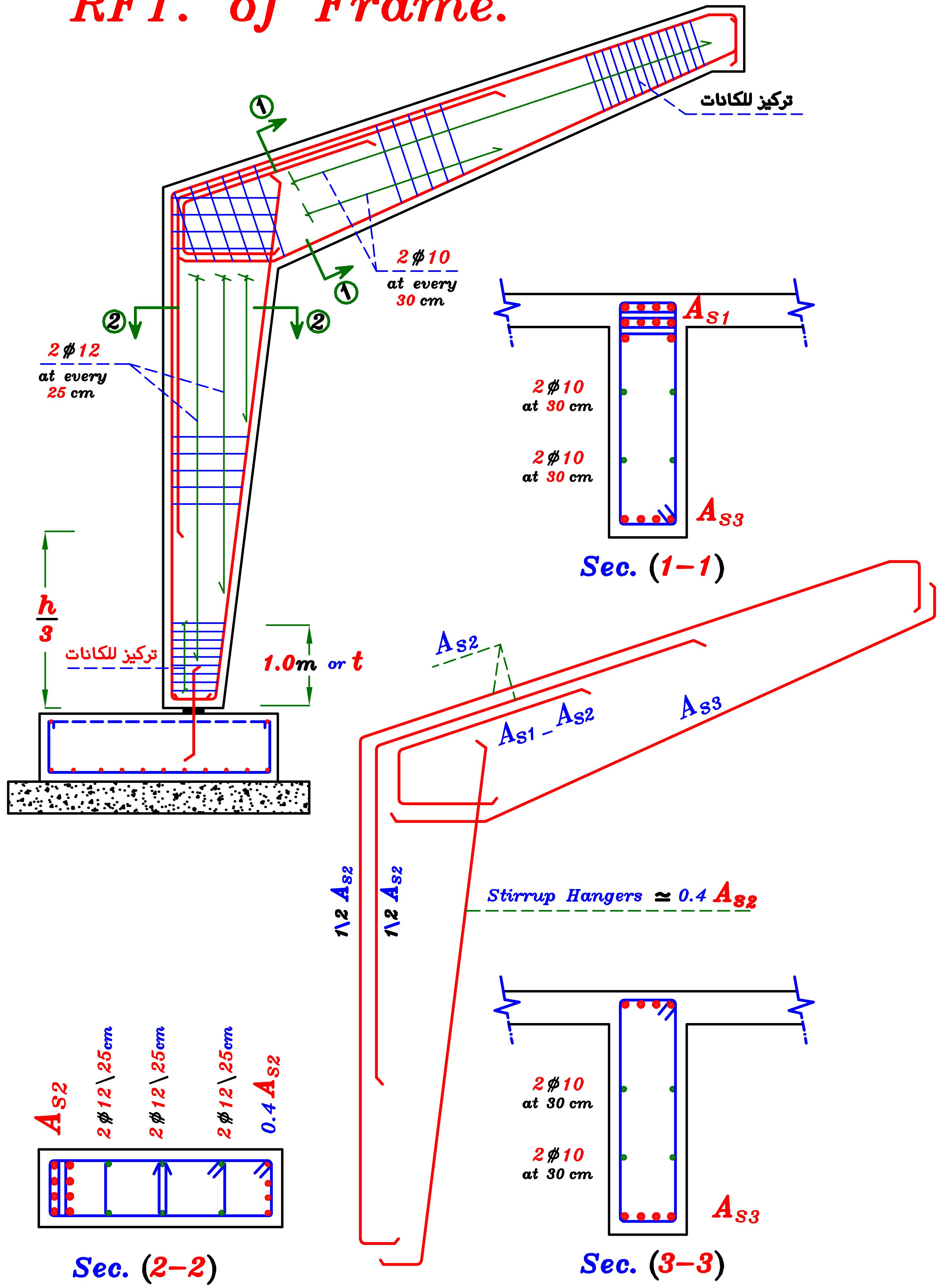


P1
P2
(−)
(−)
N.F.D.



M
3
2
1
B.M.D.

RFT. of Frame.



تركيز للكانات
1
1
2 ϕ 10
at every
30 cm
2
2
2 ϕ 12
at every
25 cm
h
3
تركيز للكانات
1.0m or t
As1
2 ϕ 10
at 30 cm
2 ϕ 10
at 30 cm
As3
Sec. (1–1)
As2
As1 – As2
As3
1\2 As2
1\2 As2
Stirrup Hangers ≃ 0.4 As2
As2
2 ϕ 12 \ 25cm
2 ϕ 12 \ 25cm
2 ϕ 12 \ 25cm
0.4 As2
Sec. (2–2)
2 ϕ 10
at 30 cm
2 ϕ 10
at 30 cm
As3
Sec. (3–3)

Straining Actions on Ring Beams.

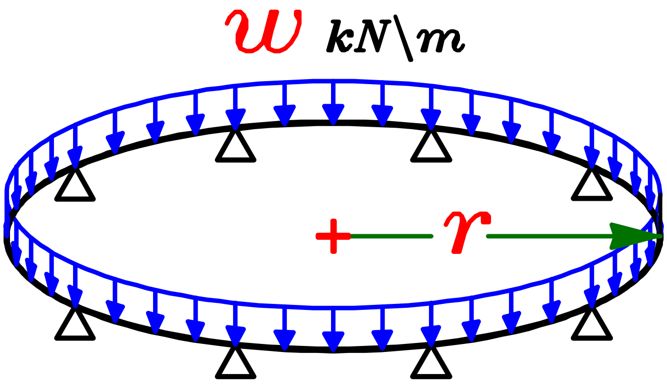
P = Total load on the beam. (kN)

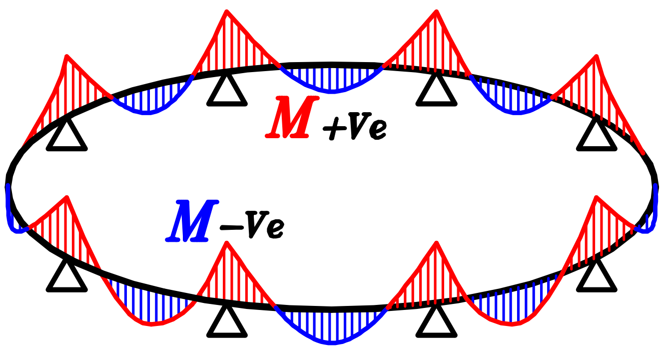
w = Load per meter. (kN/m')

r = Radius of the beam. (m)

n = Number of supports.

$$\boxed{P = w * 2\pi r}$$





لحساب ال Bending Moment & Shear Force & Torsional Moment

المؤثرين على الكمره ممكن استخدام الجدول التالى

Old Tables Page 120

No. of supports	Load on each support	Max. Shearing Force	Max. Bending Moment at C.L. of Span	Max. Bending Moment Over C.L. of Column	Max. Torsional Moment	Central angle
n	R	$Q_{max.}$	M_{+Ve}	M_{-Ve}	$M_{t\,max.}$	θ
4	P/4	P/8	0.0176 Pr	− 0.0322 Pr	0.0053 Pr	19° 21'
6	P/6	P/12	0.0075 Pr	− 0.0148 Pr	0.0015 Pr	12° 44'
8	P/8	P/16	0.0042 Pr	− 0.0083 Pr	0.0006 Pr	9° 33'
10	P/10	P/20	0.0032 Pr	− 0.0052 Pr	0.0004 Pr	7° 36'
12	P/12	P/24	0.0019 Pr	− 0.0037 Pr	0.0002 Pr	6° 21'

ال (θ) Central angle هى الزاويه المقاسه من ال Support حتى النقطه التى يوجد عندها max. Torsional moment

Data for Design of Reinforced Concrete Structures

1. Circular Beams

Supported on a number of supports (n) at equal distance under uniformaly dist^d load (pt/m')

$$M = pr^2 \left[\pi/n \, \frac{\cos \phi}{\sin \phi_0} - 1 \right]$$

$$M_t = -pr^2 \left[\pi/n \, \frac{\sin \phi}{\sin \phi_0} - \phi \right]$$

$$Q = -p.r.\phi$$

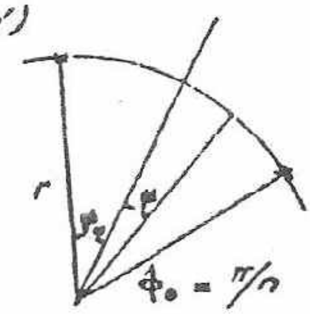


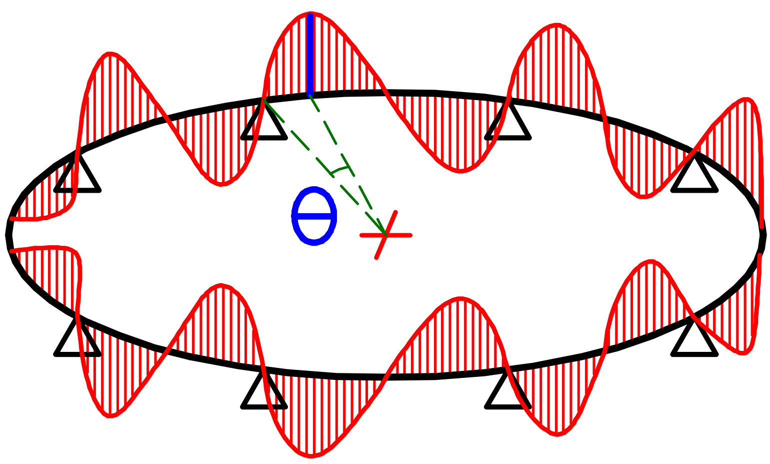
Table of extreme values

$P = 2 \pi r p$

Number of Supports (n)	Load on each column R	Max. Shearing force Q max.	Max. Bending M: At center of span M (+)	Max. Bending M: Over Support M (-ve)	Max. Torsional moment M_t	Central angle between Axis of Supports & Sec. of max. (M_t)
4	P/4	P/8	.0176 Pr	-.0322 Pr	.0053 Pr	19° 21'
6	P/6	P/12	.0075 Pr	-.0148 Pr	.0015 Pr	12° 44'
8	P/8	P/16	.0042 Pr	-.0083 Pr	.0006 Pr	9° 33'
10	P/10	P/20	.0032 Pr	-.0052 Pr	.0004 Pr	7° 36'
12	P/12	P/24	.0019 Pr	-.0037 Pr	.0002 Pr	6° 21'

$M_{t\,max.}$

Central angle (θ)



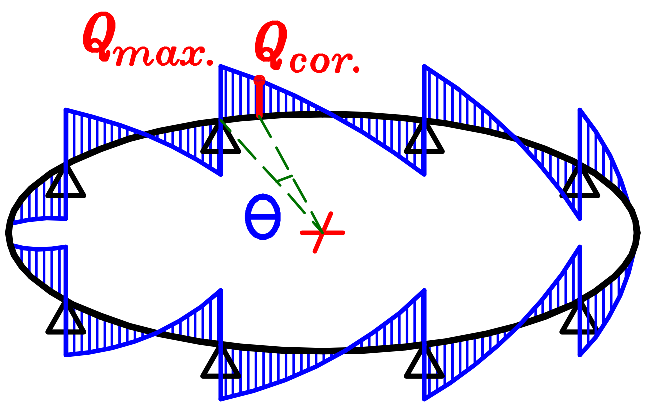
T.M.D.

ملاحظات هامه .

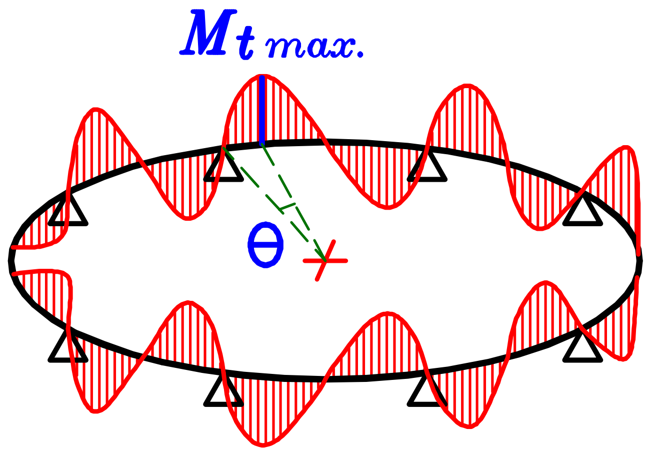
١- ال (θ) Central angle هى الزاويه المقاسه من ال Support حتى النقطه التى يوجد عندها max. Torsional moment

أى أن ال Section الذى يوجد عنده max. Torsional moment مكانه غير ال Section الذى يوجد عنده max. Shear Force

لذا عند تصميم الكانات لنتحمل Shear + Torsion نحدد قيمه $Q_{corresponding}$ و هى قيمه ال Shear Force عند ال Section الذى يوجد عنده max. Torsion



S.F.D.

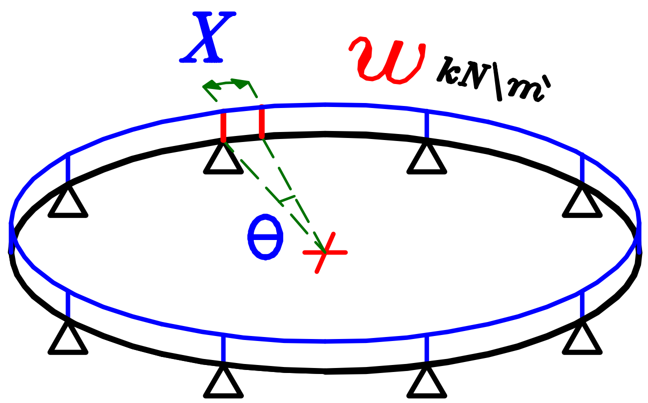


T.M.D.

$$X = r * \underset{\text{Radian}}{\theta} = r * \theta * \frac{\pi}{180}$$

$$\boxed{X = r * \theta * \frac{\pi}{180}}$$

$$\boxed{Q_{cor.} = Q_{max} - w * X}$$



ممكن للتسهيل تصميم القطاع على $(M_{t\,max.} , Q_{max})$

٢- اذا كان عدد ال **Supports** اكبر من او يساوى ١٢ $(n \geqslant 12)$ فمن الممكن :

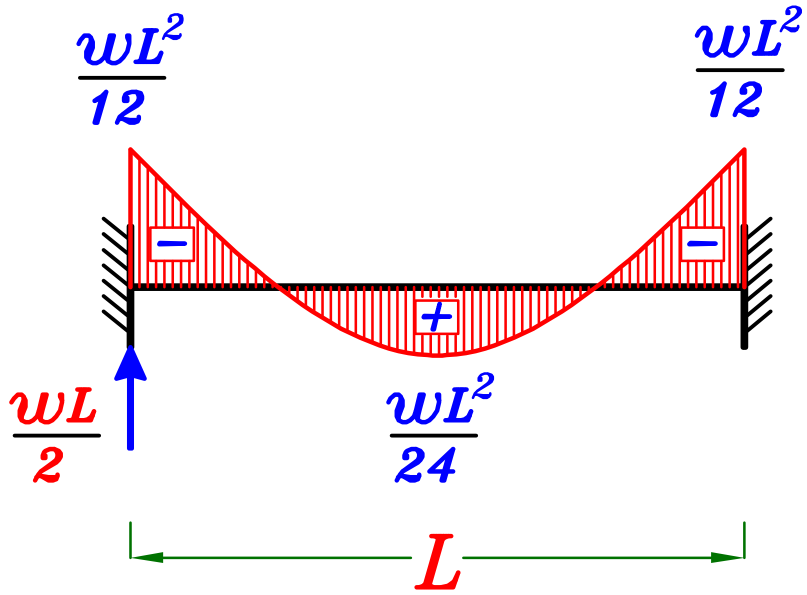
أ- نهمل عزم الالتواء (M_t) لان قيمته ستكون صغيره جدا .

ب- ممكن حساب ال **max. Shear Force** & **max. Bending Moment** كالاتى :

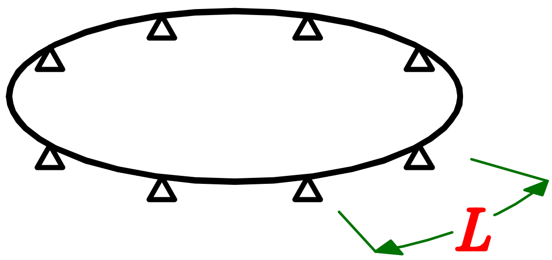
$$\boxed{max.\ M_{-Ve} = \frac{wL^2}{12}}$$

$$\boxed{max.\ M_{+Ve} = \frac{wL^2}{24}}$$

$$\boxed{Q_{max.} = \frac{wL}{2}}$$



where $\boxed{L = \frac{2\pi r}{n}}$



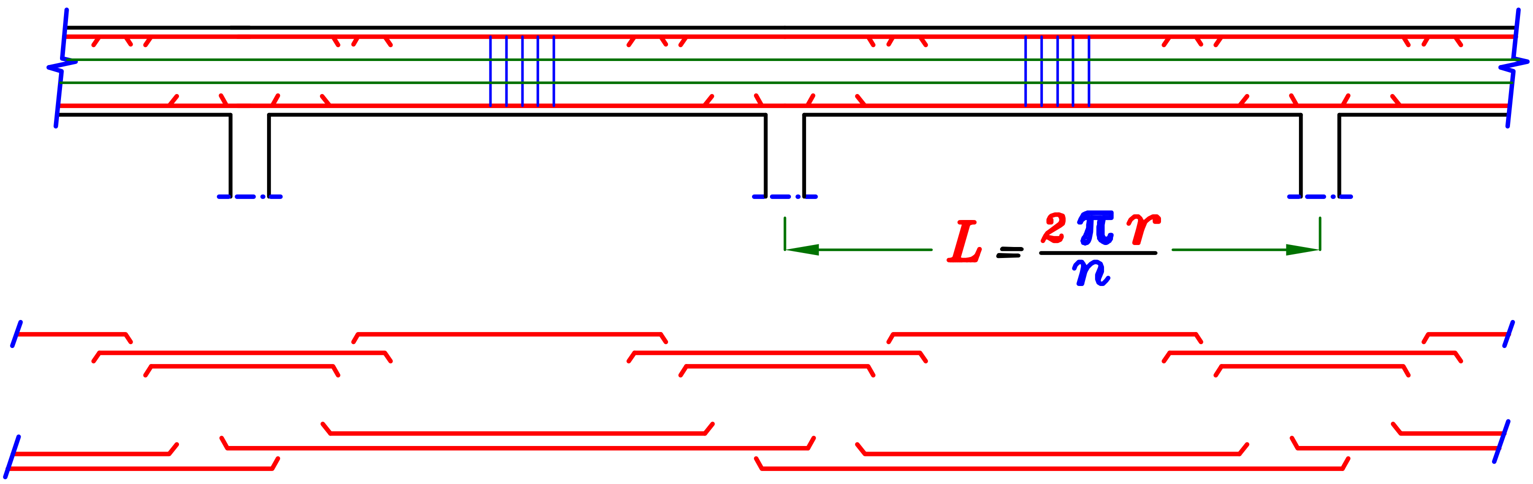
يصمم قطاعان فى الكمره على أكبر M_{+ve} و أكبر M_{-ve}

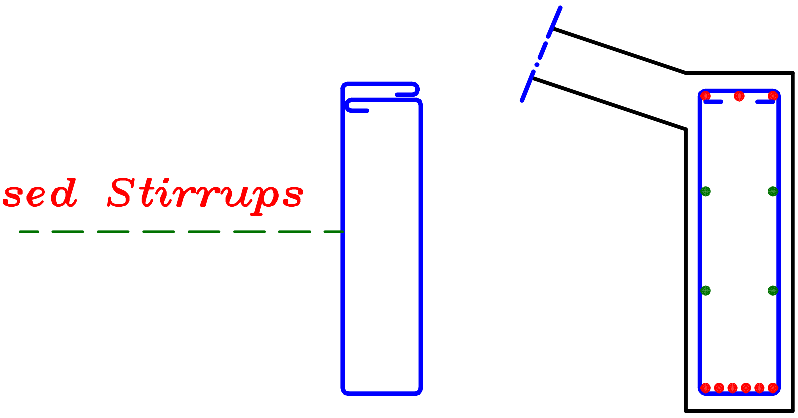
و يتم تصميم الكانات و ال Longitudinal bars على M_t , $Q_{cor.}$

و تكون القيمه النهائيه للتسليح $$\boxed{As_{total} = As + \frac{As_l}{4}}$$

و يرسم تسليح الكمره بعد فردها

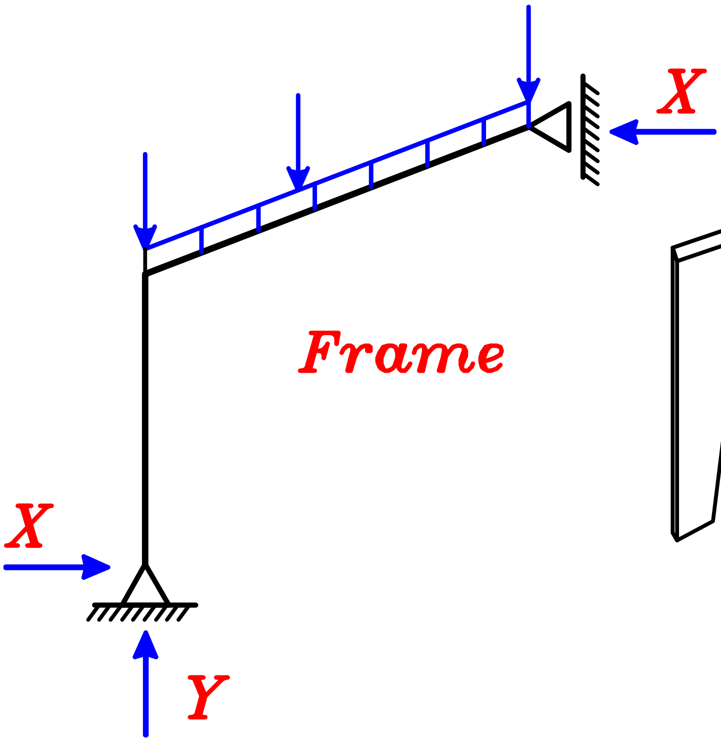
Developed Elevation of Beams.

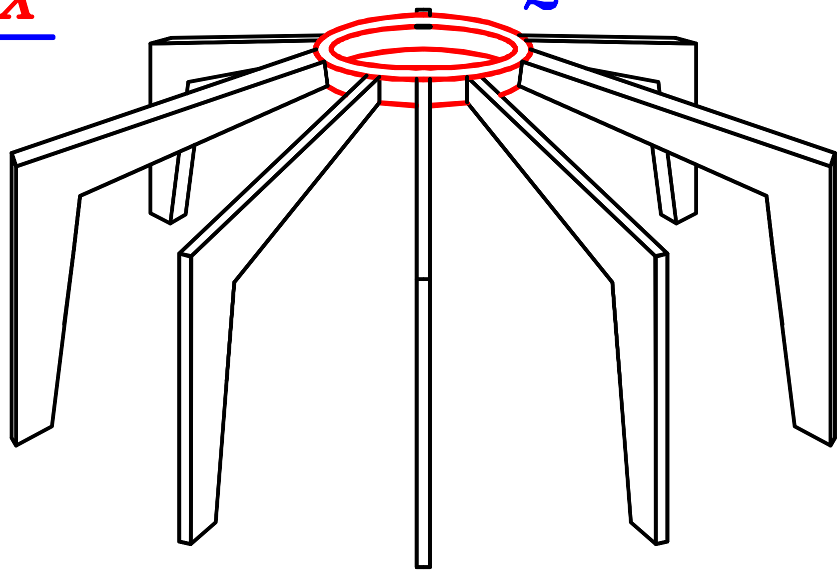




Inner Ring Beam. B_2

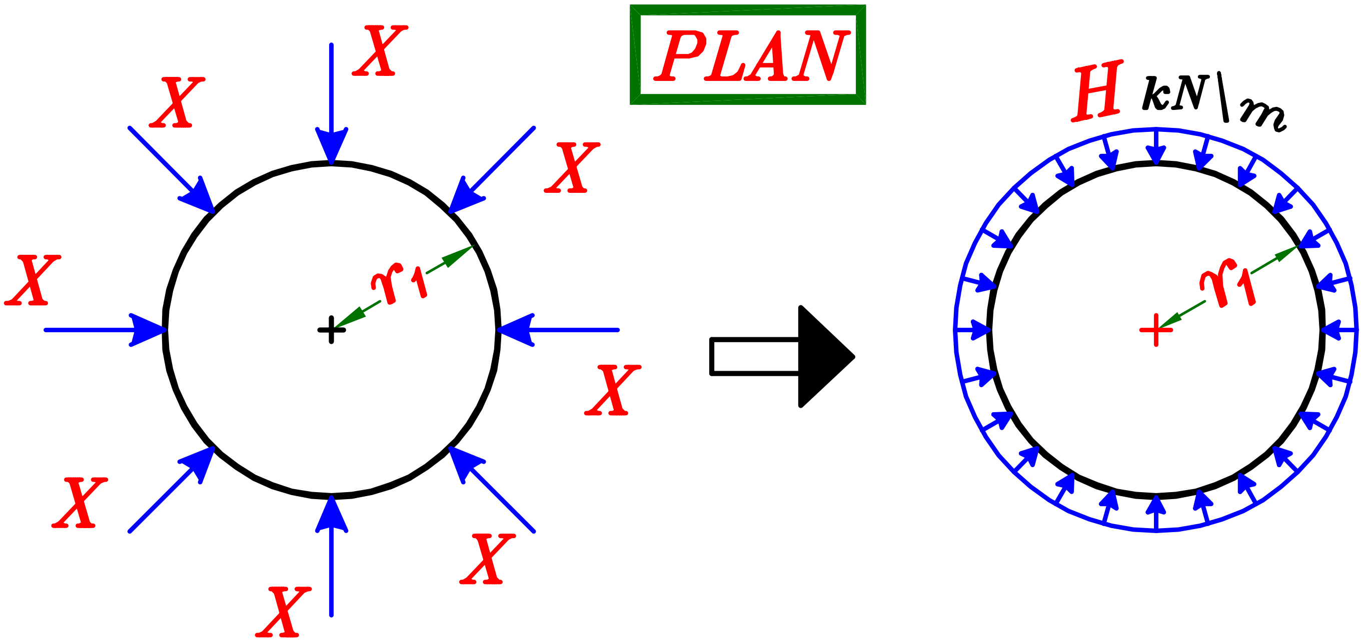
To Get Normal Force.





B_2

PLAN



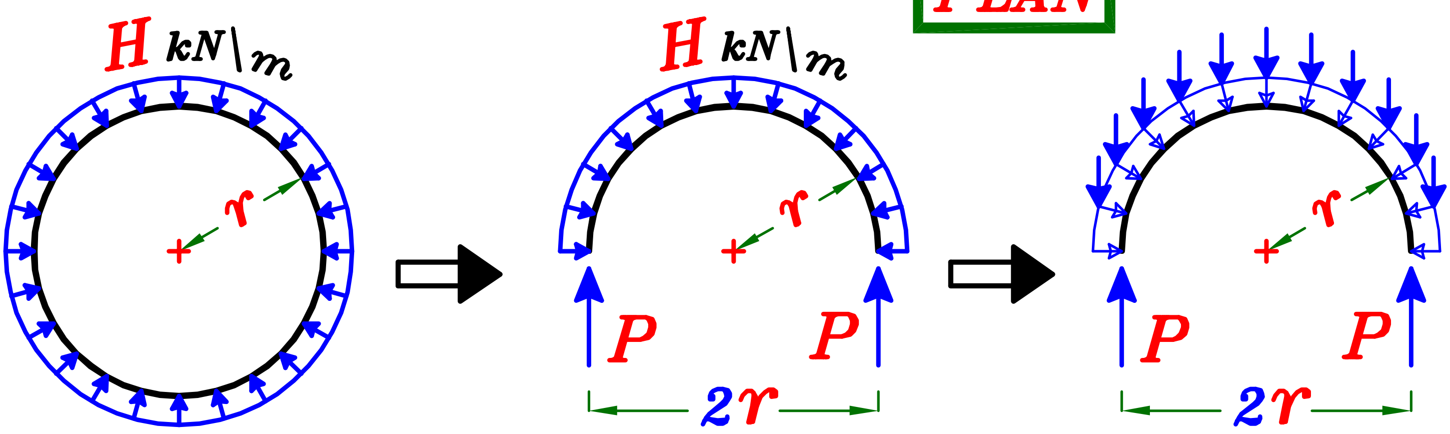
$$\boxed{H \simeq \frac{\sum X}{2\pi r_1}}$$

يتم تحويل القوى المركزه X الى distributed

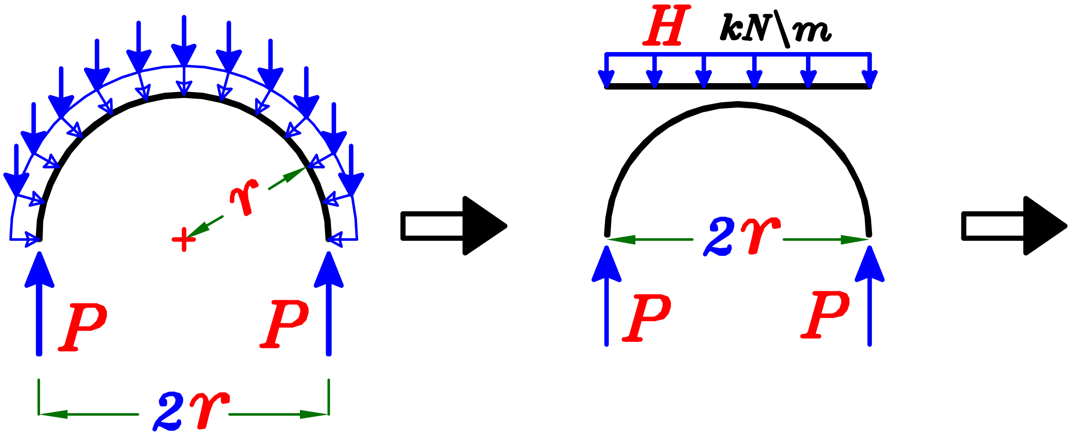
حيث X هى ال reaction الافقى لل Frame

B_2

PLAN



بتحليل كل القوى فى اتجاه P

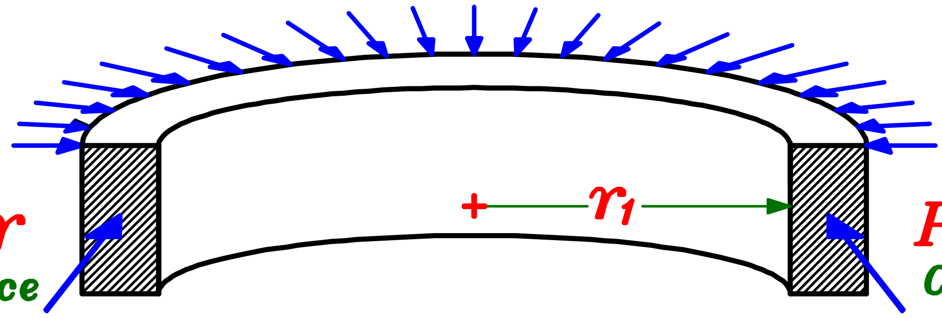


$$2P = H * 2r$$

$$\boxed{P = H * r} \; kN$$

Compression

$P = H * r$
Comp. Force



$P = H * r$
Comp. Force

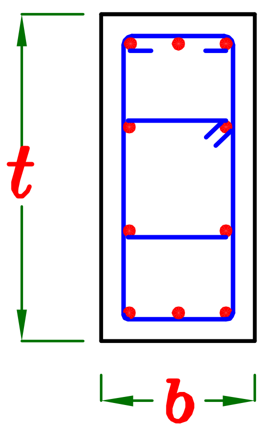
من الممكن اهمال ال **Bending Moment** و ال **Torsional Moment** لهذه الكمره

و تصمم على **Normal** فقط مثل الاعمده

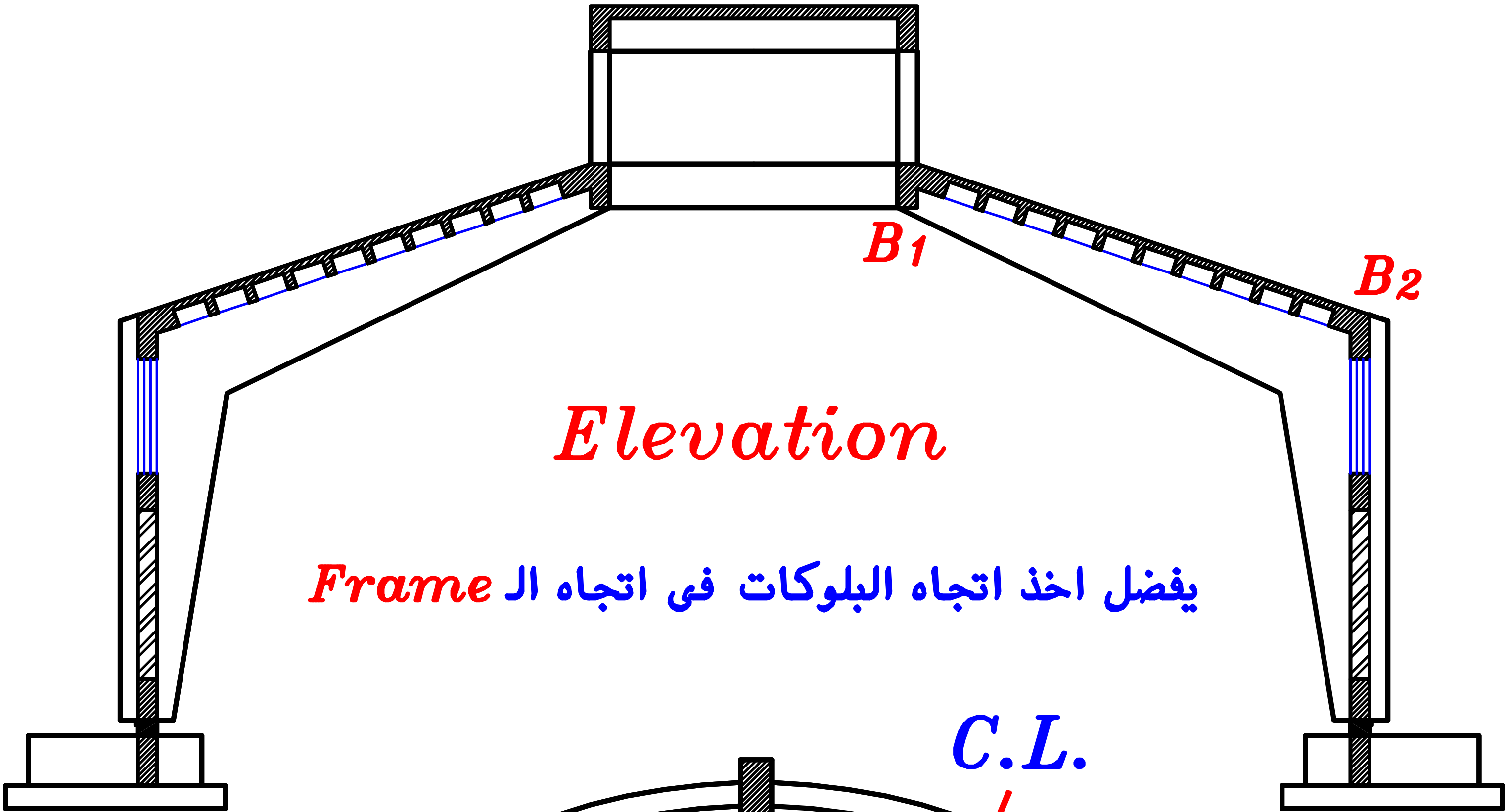
$$P_{U.L.} = 0.35 \, A_c \, F_{cu} + 0.67 \, A_s \, F_y$$

$\xrightarrow{Get} A_s$

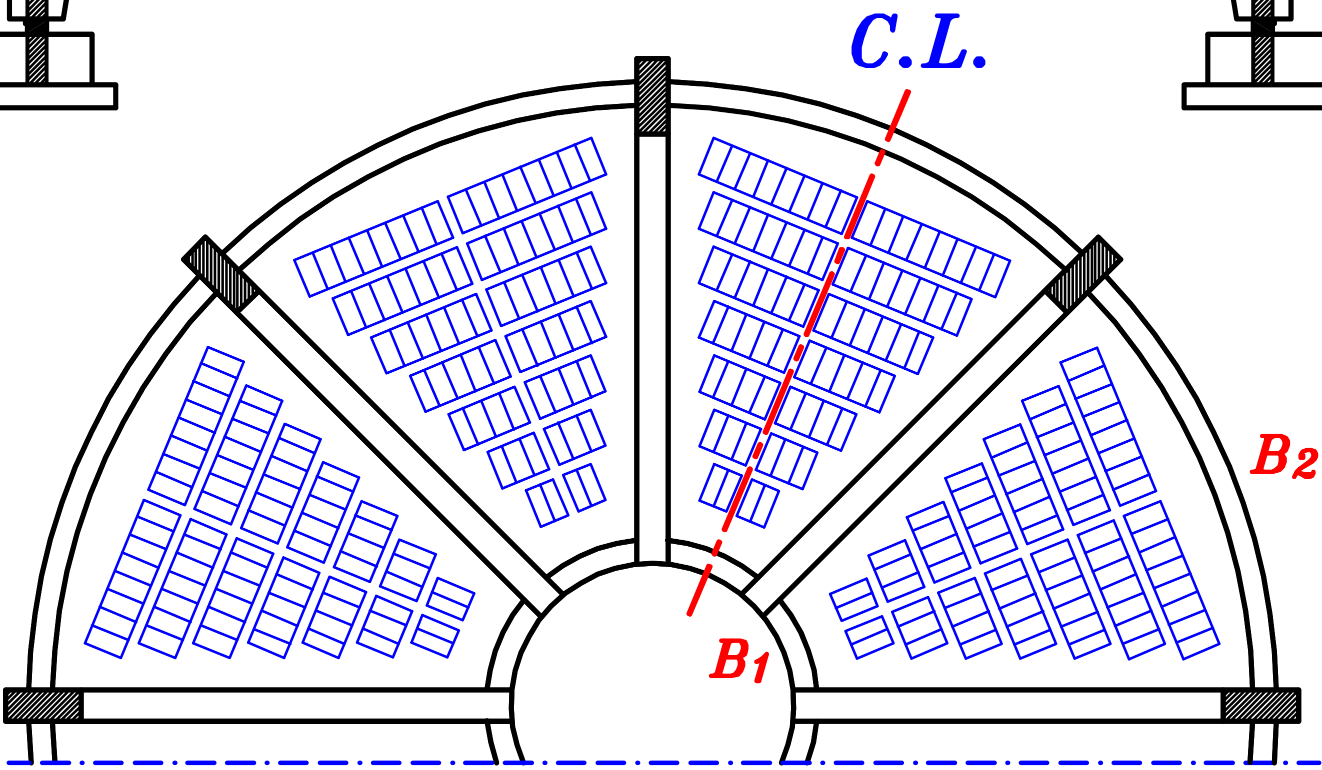
Check $A_{s_{min.}} = \frac{0.80}{100} * A_c$



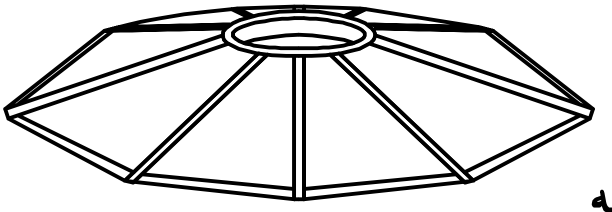
Radial Frames with H.B. Slabs.



يفضل اخذ اتجاه البلوكات فى اتجاه ال Frame

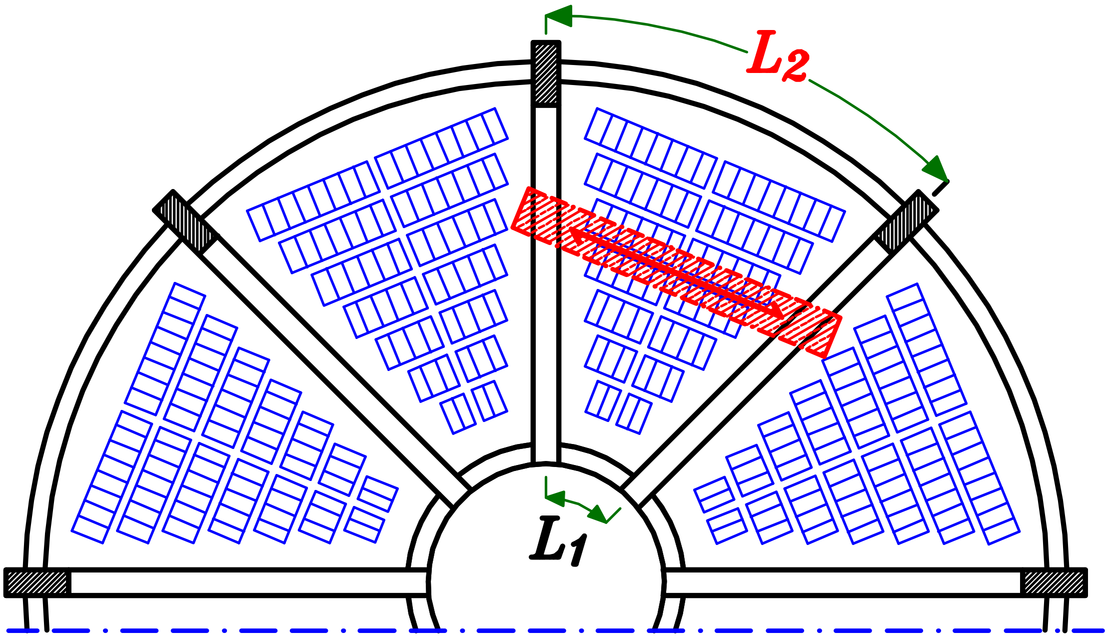


البلوكات ترسم عموديه على ال C.L.

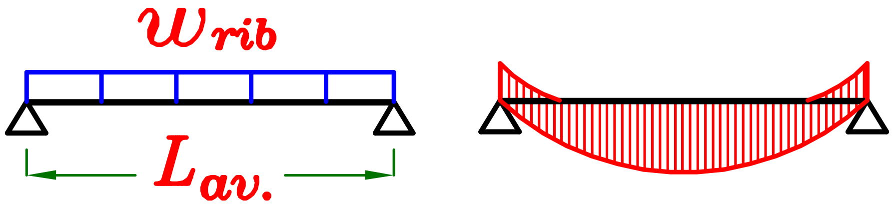


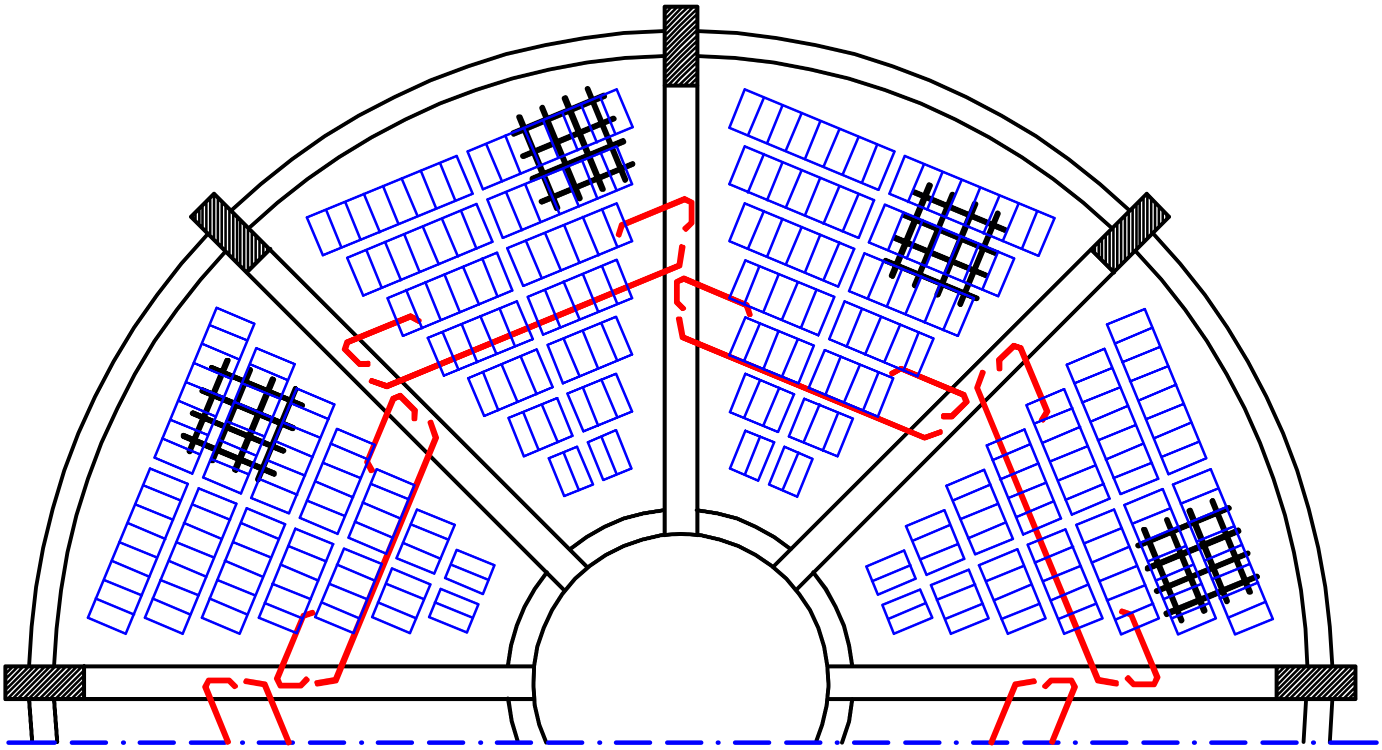
تكون الشرائح مستقيمه لان الـ ribs مستقيمه

و تكون Simple

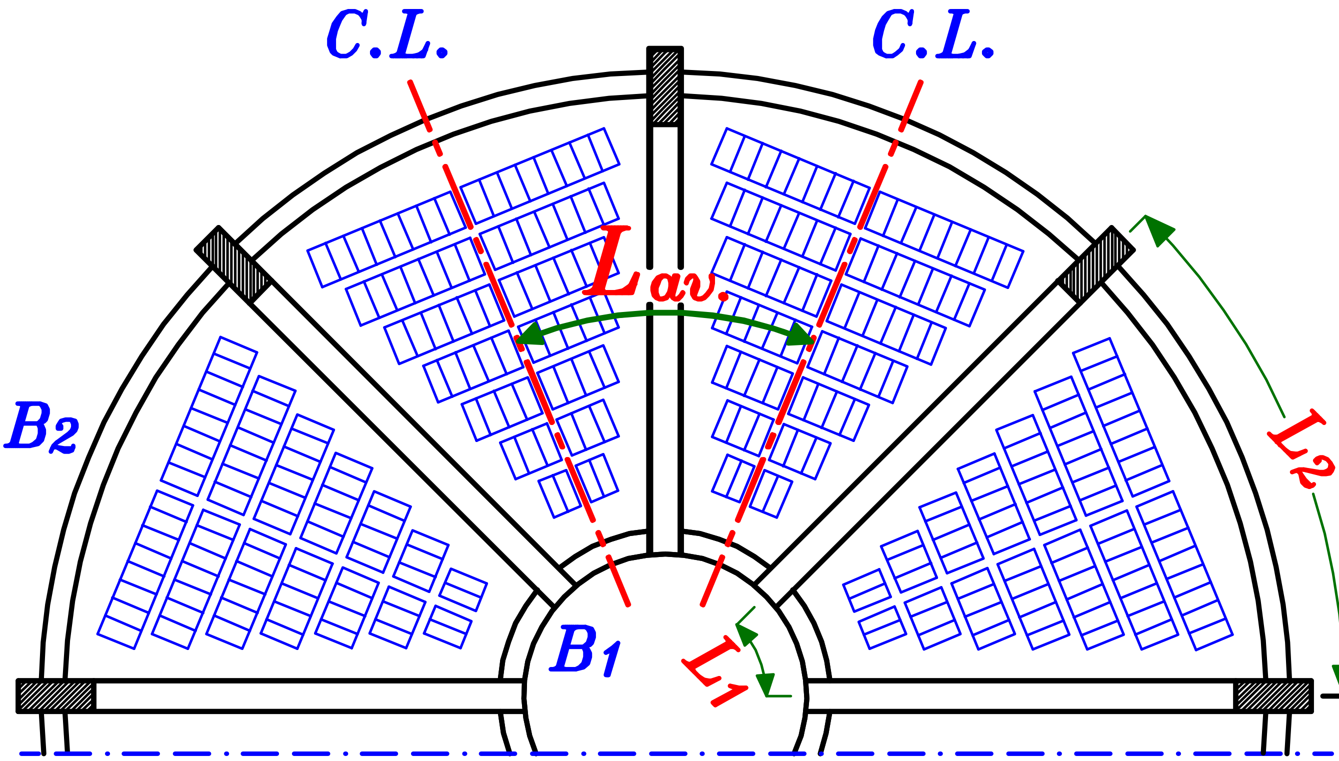


$$L_{av.} = \frac{L_1 + L_2}{2}$$





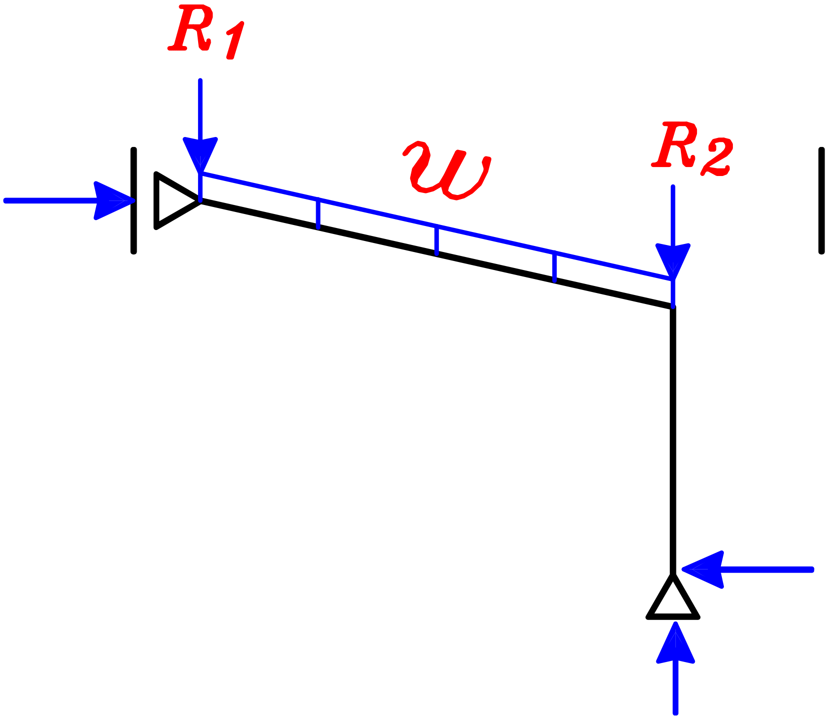
Loads on the Frame.

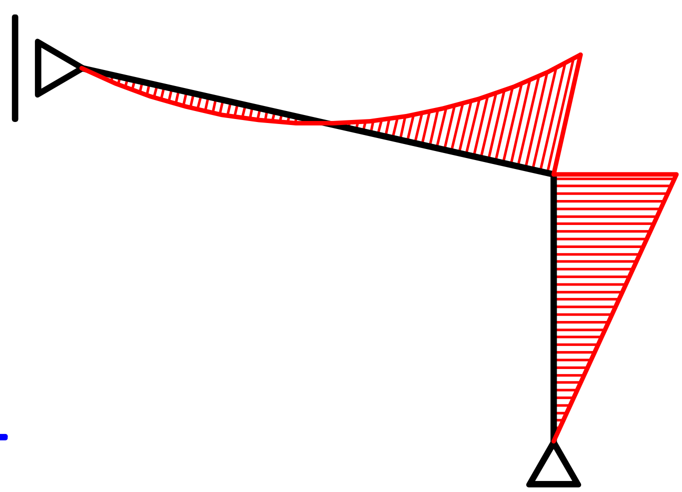


$$\boxed{L_{av.} = \frac{L_1 + L_2}{2}}$$

$$w = o.w. + \left(\frac{w_{rib}}{S}\right) L_{av.}$$

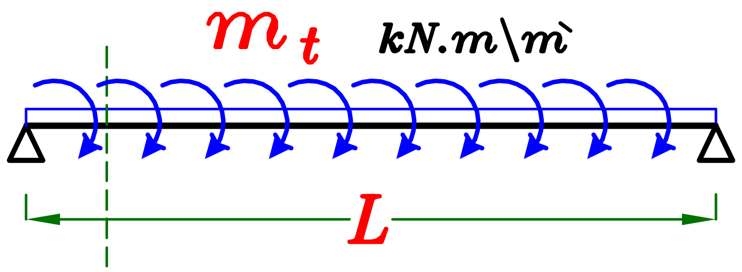
$$R_1 = \frac{o.w. * 2\pi r_1}{n} \quad , \quad R_2 = \frac{o.w. * 2\pi r_2}{n}$$

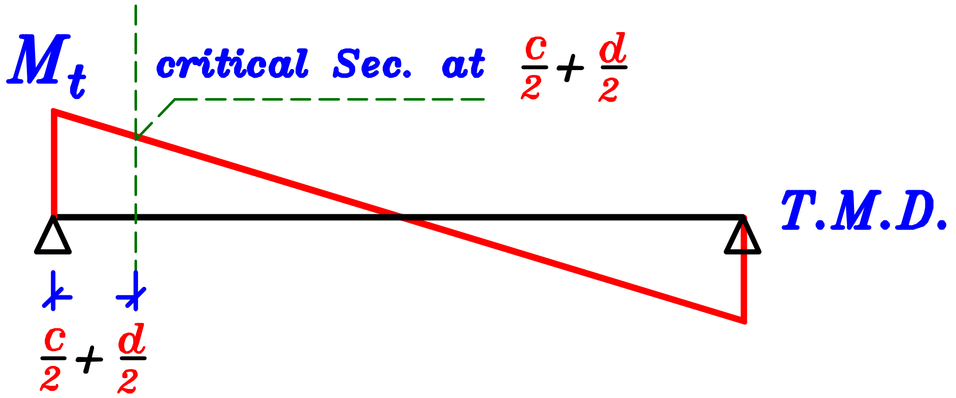




Torsion Revision.

Shear Stress due to Torsional moment. (q_{tu})





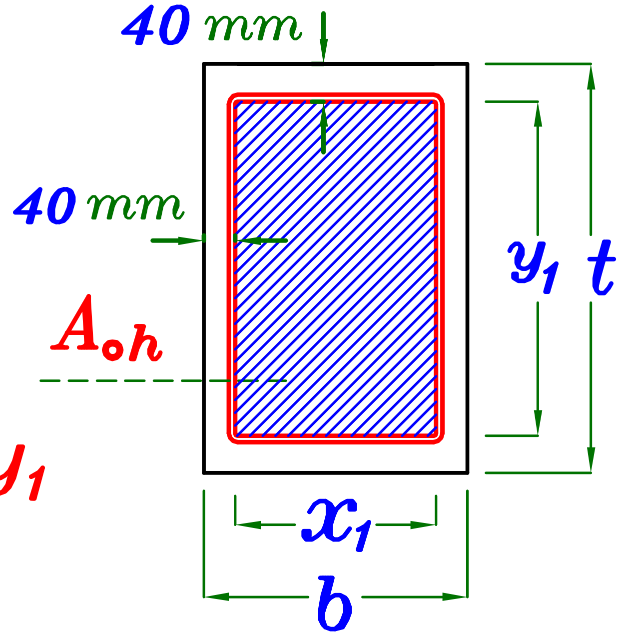
$$\boxed{q_{tu} = \frac{M_{tu}}{2\, A_o\, t_e}} \quad (N\backslash mm^2)$$

Where:

* q_{tu} $(N\backslash mm^2)$ = Actual Shear Stress due to Torsional Moment.
* M_{tu} $(N.mm)$ = Torsional Moment at Critical Section.
* A_{oh} (mm^2) = المساحه الداخليه للكانه المقاومه لل Torsion
* A_o (mm^2) = $0.85 * A_{oh}$
* P_h (mm) = محيط الكانه المقاومه لل Torsion
* t_e (mm) = $\frac{\text{المساحه الداخليه للكانه}}{\text{محيط الكانه}} = \frac{A_{oh}}{P_h}$

* $y_1 = t - 2\ Cover \simeq t - 80\ mm$

* $x_1 = b - 2\ Cover \simeq b - 80\ mm$



For R–Sec.

A_{oh} = المساحه الداخليه للكانه $= x_1 * y_1$

P_h = محيط الكانه $= 2\,(x_1 + y_1)$

$$t_e = \frac{\text{المساحه الداخليه للكانه}}{\text{محيط الكانه}} = \frac{x_1 * y_1}{2\,(x_1 + y_1)}$$

$$\therefore \boxed{q_{tu} = \frac{M_{tu}}{2\,A_o\,t_e} = \frac{M_{tu}\,(x_1 + y_1)}{0.85\,(x_1^2 * y_1^2)}}$$

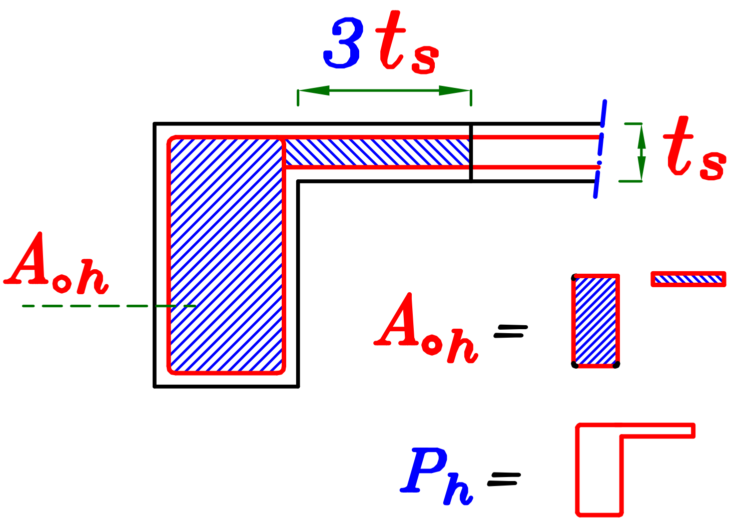
For R–Sec. only

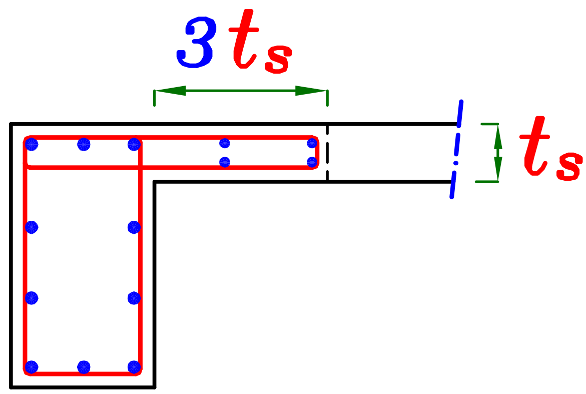
For L–Sec.

عند وجود بلاطه مع الكمره من الممكن أن نعتبر أن جزء من البلاطه يقاوم

الـ Torsion مع الكمره . و هذا الجزء يساوى تقريبا $3\,t_s$

بشرط ان يوضع فى هذا الجزء كانات لمقاومه الـ Torsion





Check Shear + Torsion.

Actual Stresses due to Shear Force. q_u

$$\boxed{q_u = \frac{Q}{b\,d}}$$

Actual Stresses due to Torsional Moment. q_{tu}

$$\boxed{q_{tu} = \frac{M_{tu}}{2\,A_o\,t_e}}$$

---

min. allowable stresses due to Shear q_{cu}

$$\boxed{q_{cu} = (0.24)\sqrt{\frac{F_{cu}}{\gamma_c}}}$$

min. allowable stresses due to Torsion q_{tu}

$$\boxed{q_{t_{min}} = (0.06)\sqrt{\frac{F_{cu}}{\gamma_c}}}$$

---

max. allowable shear stresses $q_{u\,max}$

$$\boxed{q_{umax} = (0.70)\sqrt{\frac{F_{cu}}{\gamma_c}}}$$

IF $\sqrt{q_u^2 + q_{tu}^2} > q_{u\,max} \longrightarrow$ Increase Dimensions

For Box Sections only.

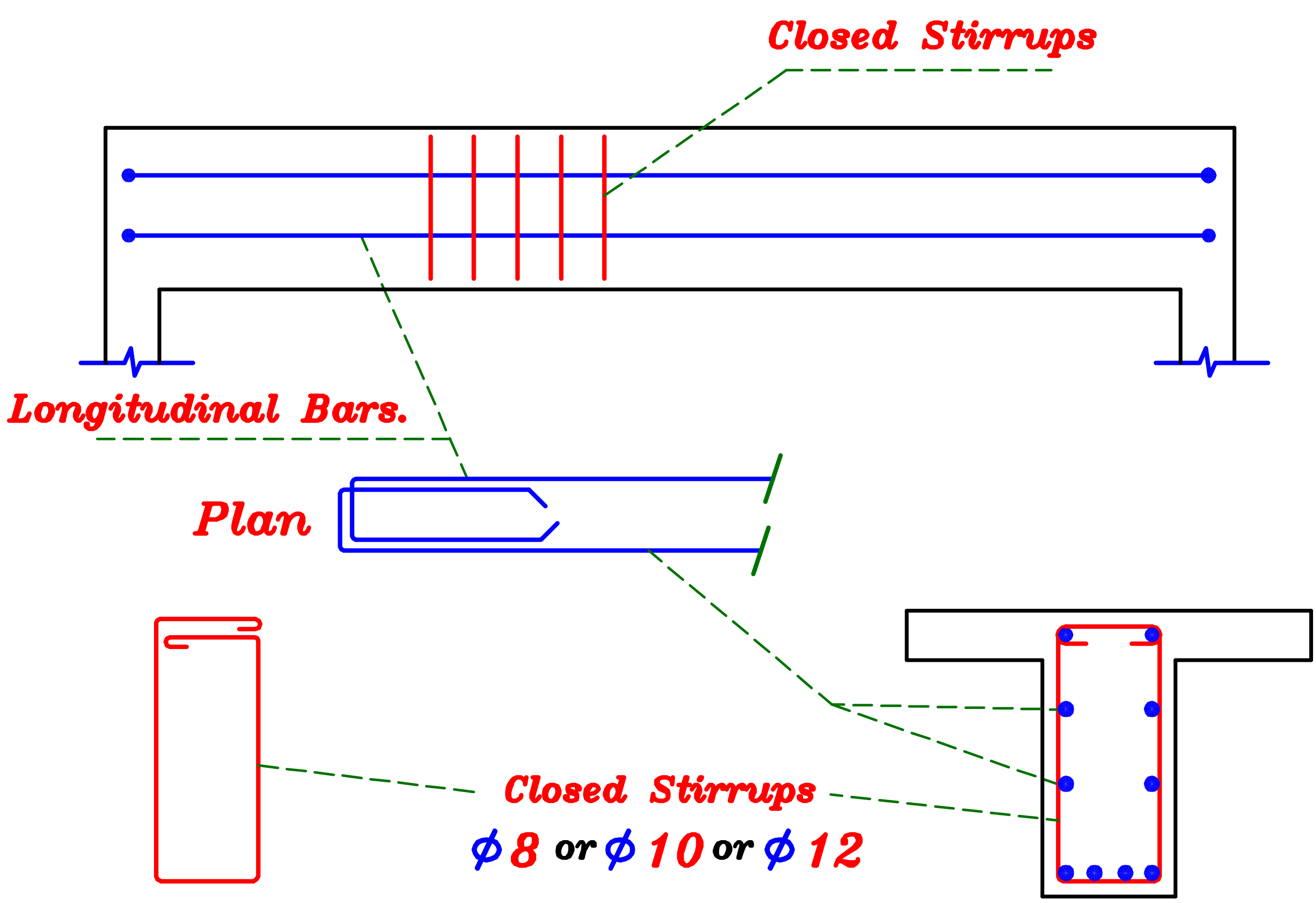
IF $q_u + q_{tu} > q_{u\,max} \longrightarrow$ Increase Dimensions

$$IF \sqrt{q_u^2 + q_{tu}^2} \leq q_{u\,max}$$

	q_u	q_{tu}	RFT.
1	$q_u < q_{cu}$	$q_{tu} < q_{t\,min}$	Use Stirrups $5 \phi 8 \backslash m'$
2	$q_u > q_{cu}$	$q_{tu} < q_{t\,min}$	Use RFT. to resist $\left(q_u - \frac{q_{cu}}{2}\right)$
3	$q_u < q_{cu}$	$q_{tu} > q_{t\,min}$	Use RFT. to resist (q_{tu})
4	$q_u > q_{cu}$	$q_{tu} > q_{t\,min}$	Use RFT. to resist $\left(q_u - \frac{q_{cu}}{2}\right) + (q_{tu})$

How to Resist Torsion ??

1. Closed Stirrups. — ١ كانات مغلقة .
2. Longitudinal Bars. — ٢ أسياخ طوليه .



Case ③ $q_u < q_{cu}$, $q_{tu} > q_{t\,min}$

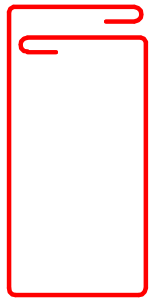
Use Shear RFT. to resist Shear Stresses $\left(q_{tu} - \frac{q_{t\,min}}{2}\right)$ applied From Torsional moment.

---

① Closed Stirrups.

$$\boxed{A_{str} = \frac{M_{tu}\ S_t}{(1.7)\ A_{oh}\left(\frac{F_y}{\gamma_s}\right)}}$$

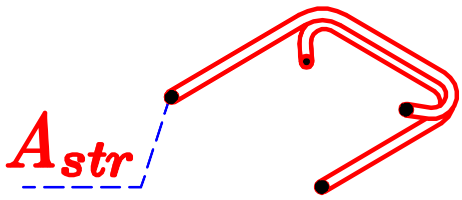
حفظ



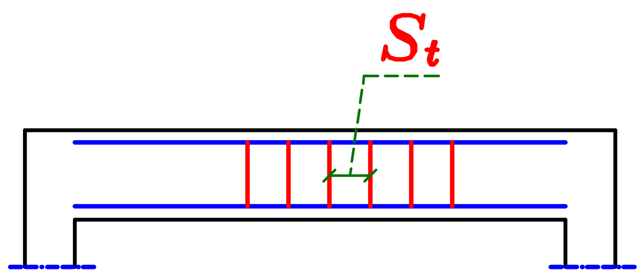
Closed Stirrup

Where:

* A_{str} مساحه مقطع سيخ الكانه



ϕ	A_{str}
ϕ 8	50.3 mm^2
ϕ 10	78.5 mm^2
ϕ 12	113 mm^2



ملحوظه :

- ممكن إستخدام كانات حتى ϕ 12 فى ال Torsion

- كانات ال Torsion تكون الكانات الخارجيه فقط .

* S_t المسافه الطوليه بين كانات ال Torsion

$$S_t = (100\ mm \longrightarrow 200\ mm)$$

In the equation choose $\phi \longrightarrow A_{str} = \checkmark$

Then get $S_t = (100\ mm \longrightarrow 200\ mm)$

- IF $S_t \geqslant 200\ mm \xrightarrow{use} 5\phi \checkmark \backslash m'$
- IF $S_t < 100\ mm$ Choose bigger ϕ
- IF $100\ mm < S_t < 200\ mm \xrightarrow{Get}$ No of stirrups $\backslash m' = \frac{1000}{S_t}$

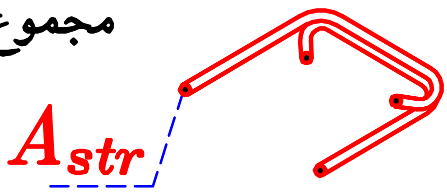
---

② Longitudinal Bars.

$$\boxed{A_{sl} = \frac{A_{str} * P_h}{S_t} \left(\frac{F_{y\ str.}}{F_{y\ L.b.}} \right)}$$

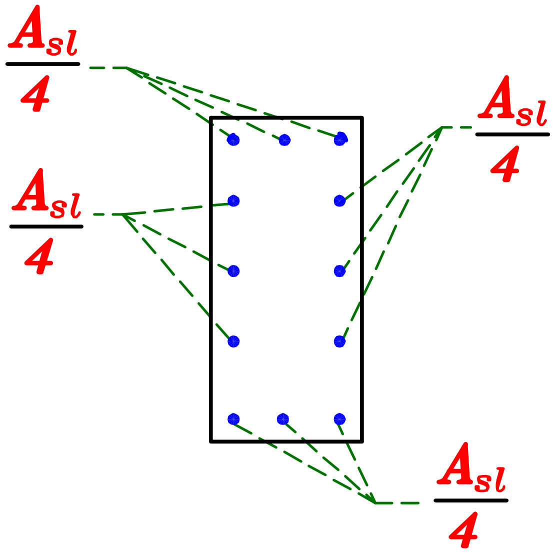
Where:

* A_{sl} مجموع مساحه مقطع الأسياخ الطوليه كلها.
* A_{str} مساحه مقطع سيخ الكانه.

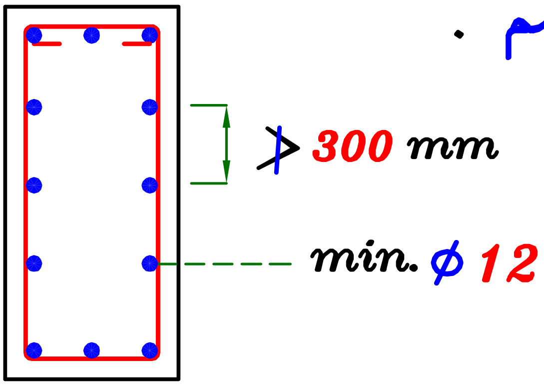


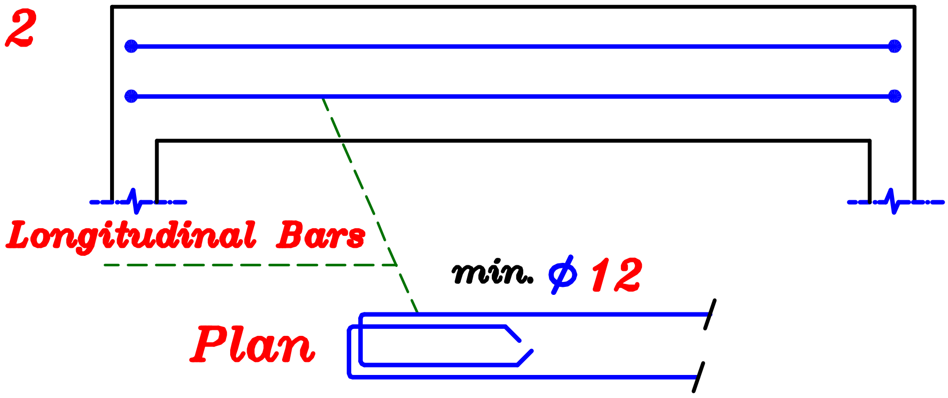
* $F_{y\ str.} = F_y$ For stirrups. $\simeq 240\ N\backslash mm^2$
* $F_{y\ L.b.} = F_y$ For Longitudinal bars. $\simeq 360\ N\backslash mm^2$

- توزع الأسياخ على محيط القطاع بانتظام .



- المسافه بين الأسياخ لا تزيد عن ٣٠٠ مم .
- أقل قطر للسيخ $\phi 12$





اذاً لرص تسليح ال *Longitudinal Bars*

يتم زياده مساحه $\frac{A_{sl}}{4}$ على مساحه التسليح الرئيسى للعزوم
ثم نحدد بعدها عدد الاسياخ الكليه و اقطارها .

يتم زياده مساحه $\frac{A_{sl}}{4}$ على مساحه ال *Stirrup Hangers*
ثم نحدد بعدها عدد الاسياخ الكليه و اقطارها .

يتم وضع اسياخ جانبيه بدل ال *Shrinkage Bars*
قيمتها $1 \phi 12$ كل ٣٠٠ مم و توضع حتى لو كان $t < 700\ mm$

Case ④ $q_u > q_{cu}$, $q_{tu} > q_{tmin}$

Use Shear RFT. to resist Shear Stresses (q_{tu}) applied From Torsional moment.

+ Shear RFT. to resist Shear Stresses $\left(q_u - \frac{q_{cu}}{2}\right)$ applied From Shear Force.

① Closed Stirrups.

ⓐ Torsion.

$$\boxed{A_{str} = \frac{M_{tu}\ S_t}{(1.7)\ A_{oh}\left(\frac{F_y}{\gamma_s}\right)}} \longrightarrow A_{str} = \checkmark * S \quad ---①$$

كانات خارجيه فقط

A_{str} هى مساحه سيخ الكانه الخارجيه التى نحتاجها لمقاومه ال Torsion فقط.

ⓑ Shear.

$$\boxed{q_u - \frac{q_{cu}}{2} = \frac{n\ A_s (F_y \backslash \gamma_s)}{b\ S_s}} \longrightarrow A_s = \checkmark * \frac{S}{n} \quad ---②$$

كانات خارجيه و ممكن كانات داخليه

A_s هى مساحه مقطع سيخ واحد من الكانه الخارجيه أو الداخليه التى نحتاجها لمقاومه ال Shear فقط.

– نبدأ أولاً بفرض أن عدد فروع الكانه يساوى فرعين $n = 2$ و عدد الكانات فى المتر = من (٥ ⟵ ١٠) أسياخ/م ثم نحسب $S = \frac{1000}{No\ of\ st.\backslash m}$ ثم نحسب A_{str} , A_s

و تكون مساحه السيخ من الكانات الخارجيه $A_{s_{outer}} = A_{str} + A_s$

– فاذا كانت $113\ mm^2 \geqslant A_{s_{outer}}$ أى أن $\phi 12 \geqslant \phi_{Outer}$

فنختار $\phi_{Outer} = \phi 8$ or $\phi 10$ or $\phi 12$ و لا توجد كانات داخليه

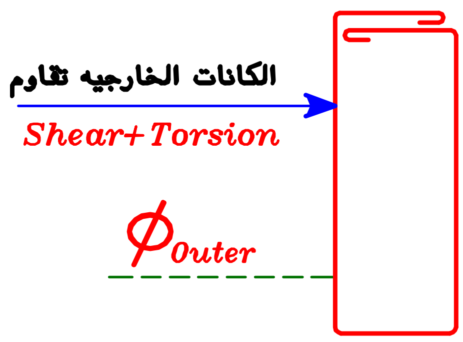
– أما اذا كانت $A_{s_{outer}} > 113\ mm^2$ فنختار عدد كانات أكثر فى المتر أو نأخذ $n = 4$

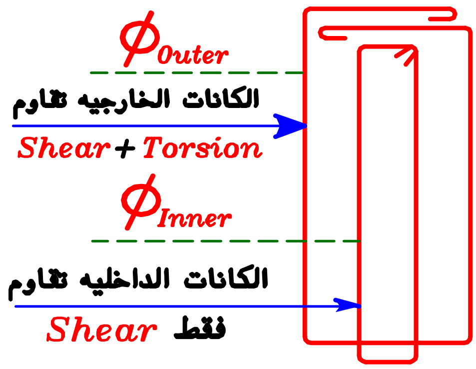
ثم تحديد قيمه A_s و تحديد قيمه $A_{s_{outer}} = A_{str} + A_s$

و تحديد قيمه $A_{s_{inner}} = A_s$

ترتيب اختيار الفروض لـ n , S

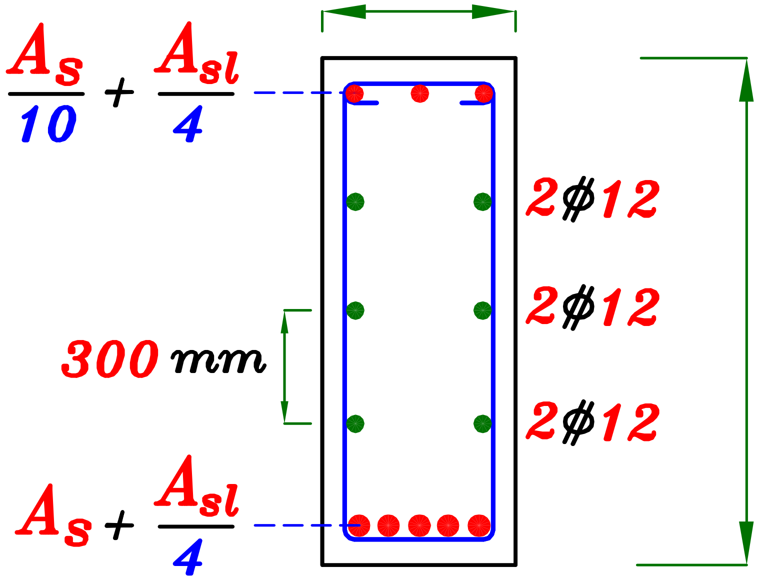
Assumption No.	n	No. of stirrups\m	$S_s = S_t$ (mm)
1	2	5.0	$\frac{1000}{5.0}$
2	2	6.0	$\frac{1000}{6.0}$
3	2	7.0	$\frac{1000}{7.0}$
4	2	8.0	$\frac{1000}{8.0}$
5	2	9.0	$\frac{1000}{9.0}$
6	2	10	$\frac{1000}{10}$
7	4	5.0	$\frac{1000}{5.0}$
8	4	6.0	$\frac{1000}{6.0}$
9	4	7.0	$\frac{1000}{7.0}$
10	4	8.0	$\frac{1000}{8.0}$
11	4	9.0	$\frac{1000}{9.0}$
12	4	10	$\frac{1000}{10}$

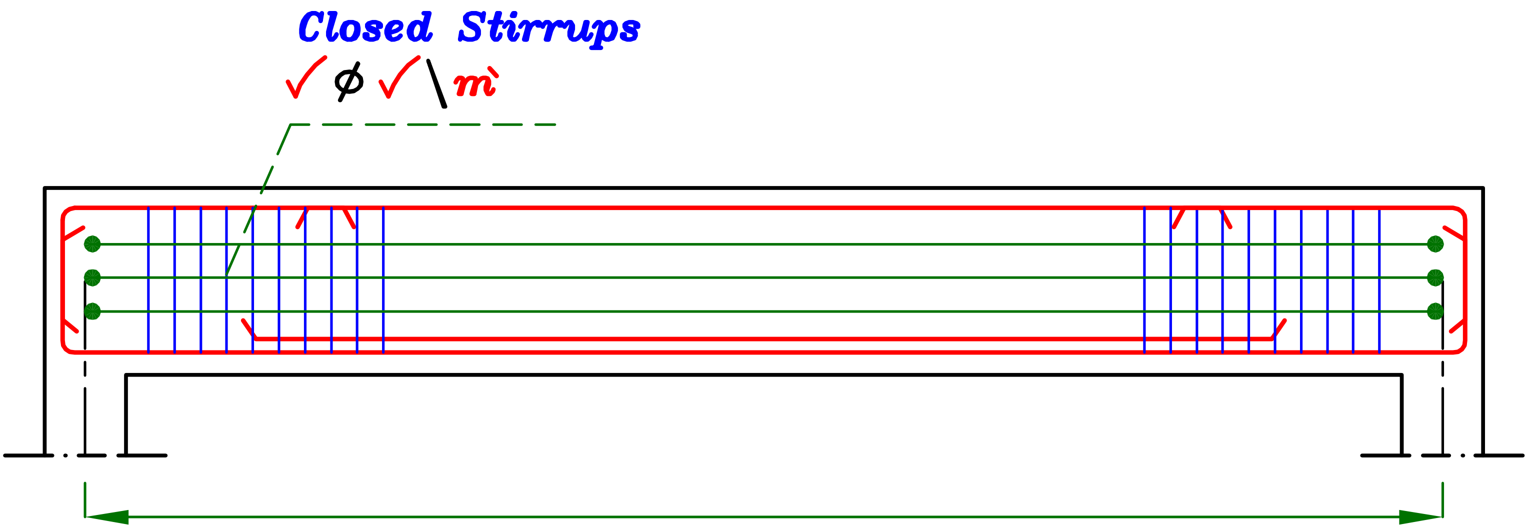




② Longitudinal Bars. Torsion only

$$A_{sl} = \frac{A_{str} * P_h}{S_t} \left(\frac{F_{y\,str.}}{F_{y\,L.b.}} \right)$$

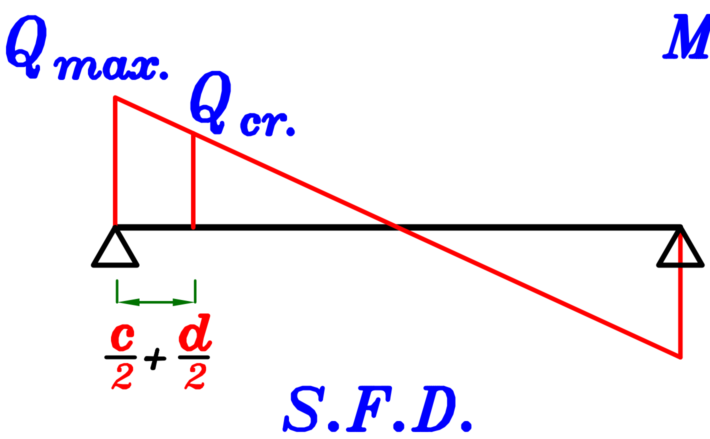


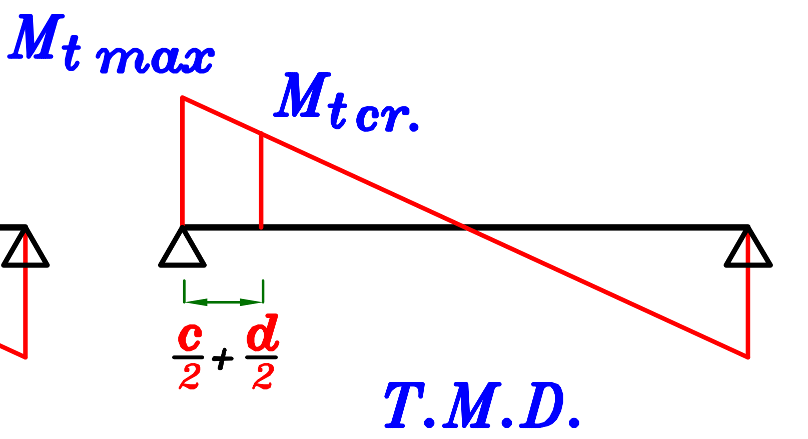


عند تصميم كانات قطاع على **Shear** او ال **Shear & Torsion**

و كانت ابعاد القطاع معطى فى المسأله

يفضل استخدام $Q_{cr.}$ و ليس ال Q_{max} و استخدام $M_{t\,cr.}$ و ليس $M_{t\,max}$

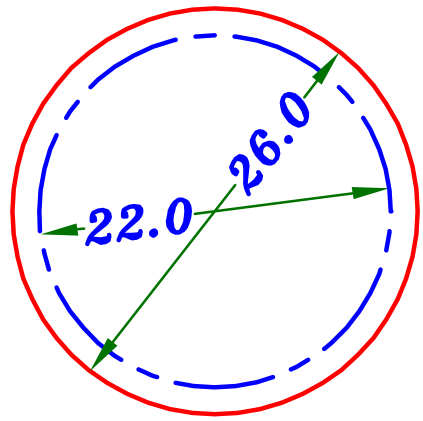




Example.

For the Circular area with Diameter 22.0 m

Columns are allowed only on the Axis



$F_{cu.} = 25\ N\backslash mm^2$, $F_y = 360\ N\backslash mm^2$

$L.L. = 1.0\ kN\backslash m^2$, $F.C. = 1.50\ kN\backslash m^2$

use a skylight with height 2.0 m & diameter 4.0 m

Clear height = 5.0 m

Foundation Level. = − 2.0 m

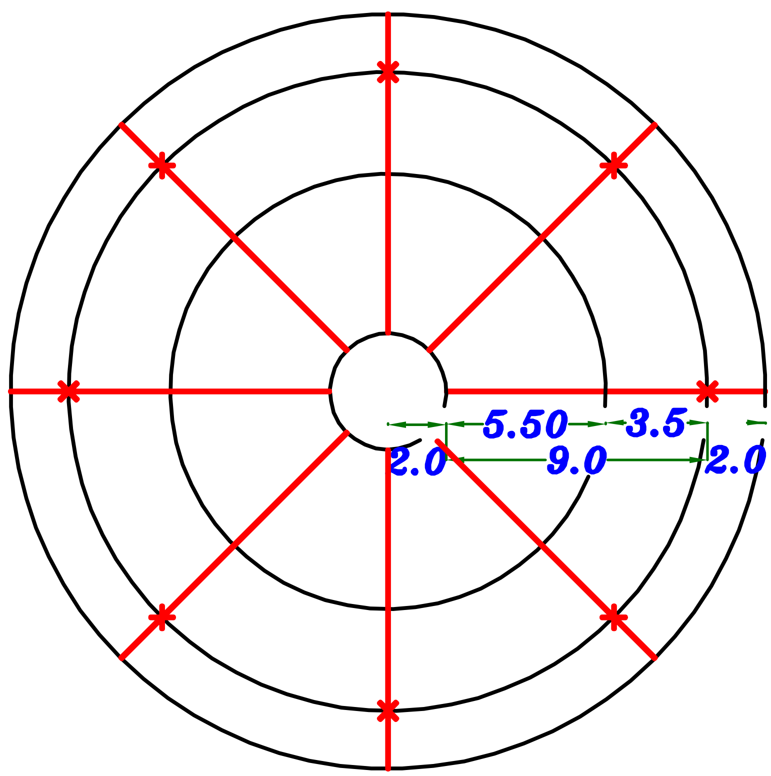
Req.

1 − Cover this area with a suitable system.

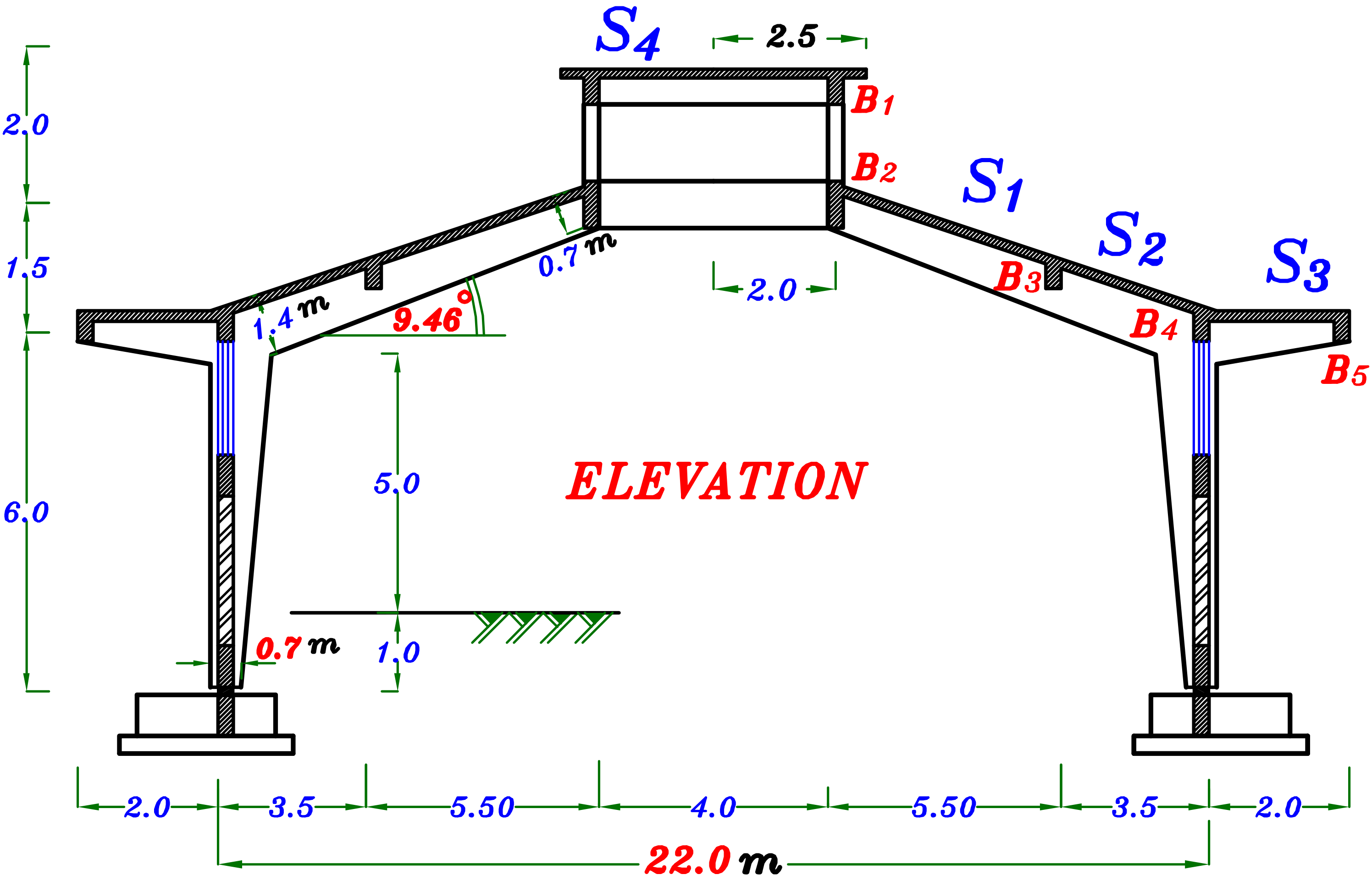
2 − Draw Concrete dimensions in Elevation.

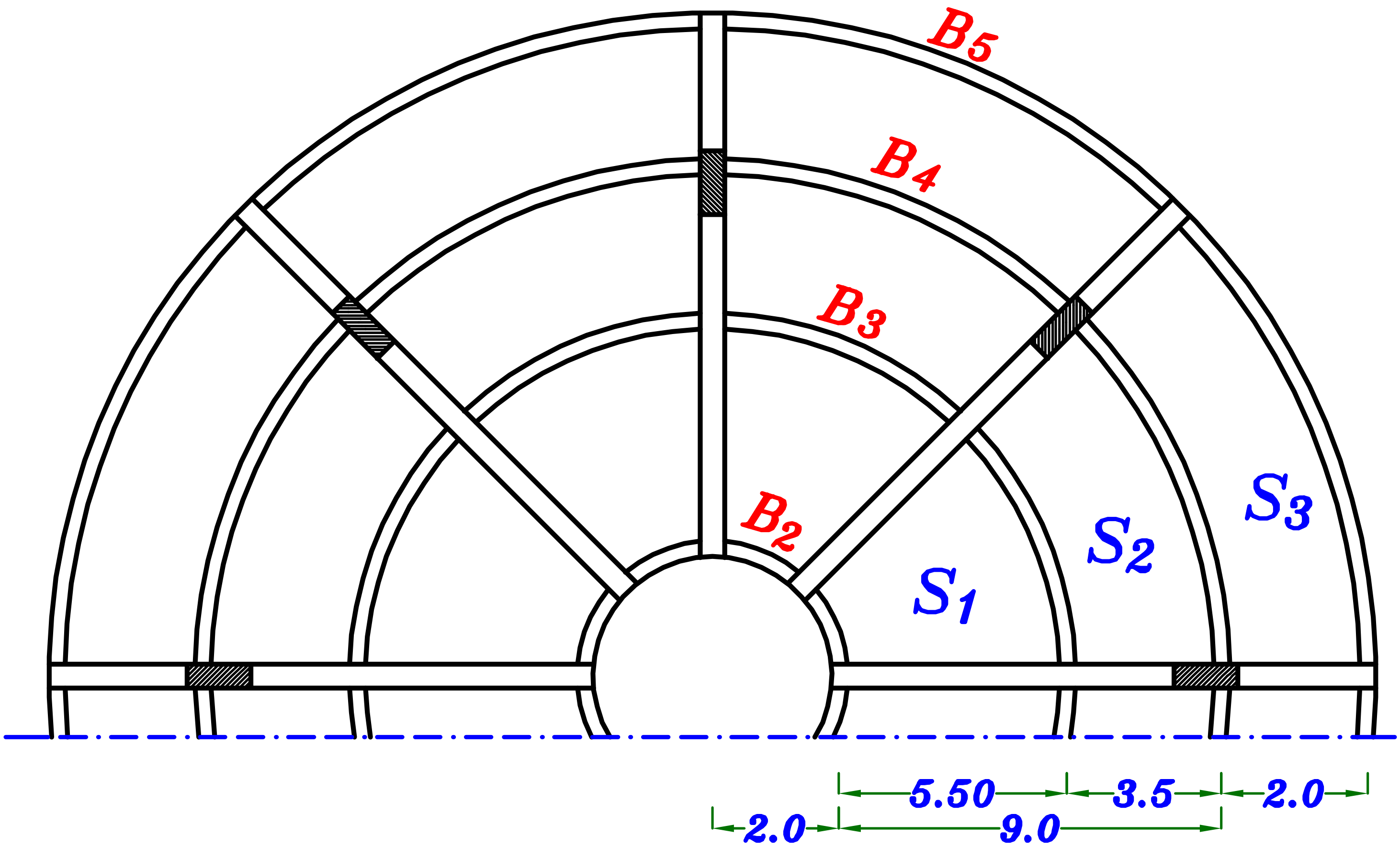
3 − Design all concrete elements & draw Details of RFT.

Use 8 Radial Frames & Solid Slabs



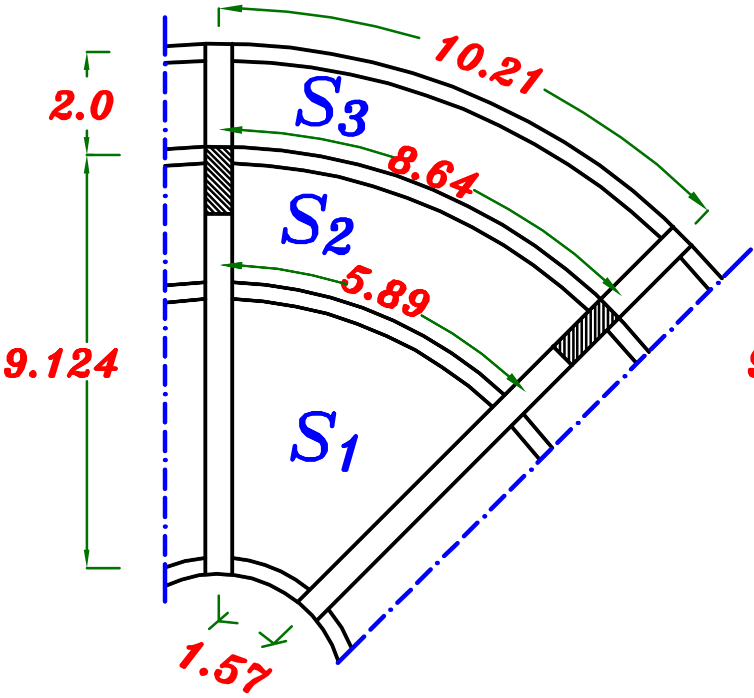
Concrete Dimensions.

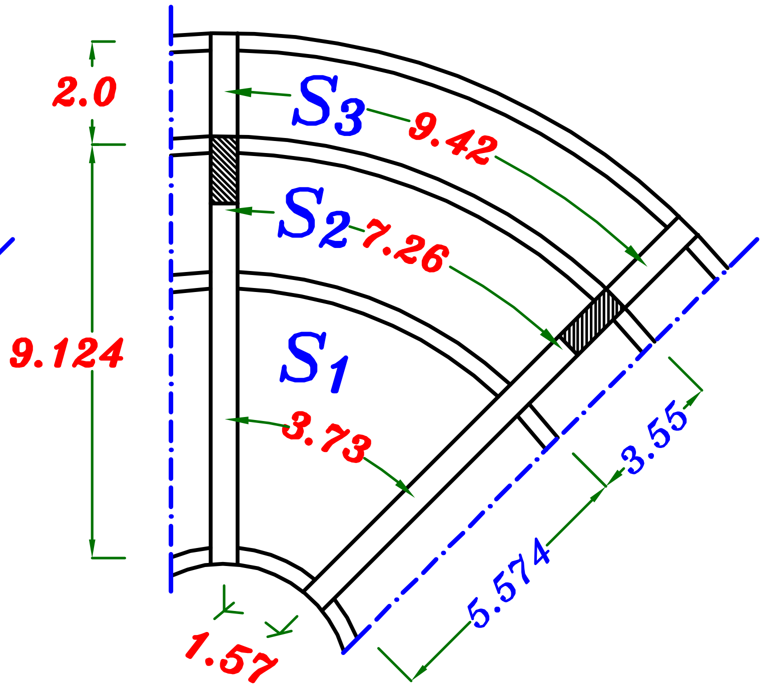




HALF PLAN

Design the Slab.





$$L_{av\,1} = \frac{1.57 + 5.89}{2.0} = 3.73\ m$$

$$L_{av\,2} = \frac{5.89 + 8.64}{2.0} = 7.26\ m$$

$$L_{av\,3} = \frac{8.64 + 10.21}{2.0} = 9.42\ m$$

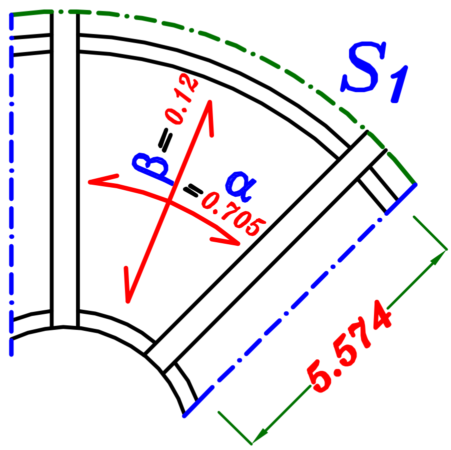
$$S_1 = (5.574\, m * 3.73\ m)$$

$$r = \frac{m * L}{m' * L_s} = \frac{0.87\,(5.574)}{0.76\,(3.73)} = 1.71 < 2.0 \longrightarrow \textbf{Two Way Slab.}$$

$$\alpha = 0.5\, r - 0.15 = 0.5 * 1.71 - 0.15 = 0.705$$

$$\beta = \frac{0.35}{r^2} = \frac{0.35}{1.71^2} = 0.12$$

$$t_{s1} = \frac{L_s}{45} = \frac{3730}{45} = 82.88\ mm$$

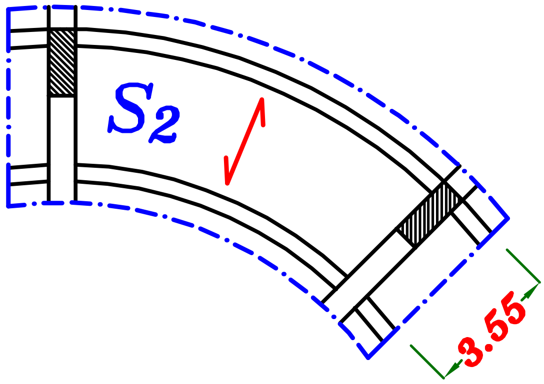


$$S_2 = (7.26\ m * 3.55\ m)$$

$$r = \frac{m * L}{m` * L_s} = \frac{0.76\,(7.26)}{0.76\,(3.55)} = 2.04 > 2.0 \longrightarrow \text{One Way Slab.}$$

S_2 is One Way Slab at 3.55 direction

$$t_{s2} = \frac{L_s}{36} = \frac{3550}{36} = 98.61\ mm$$

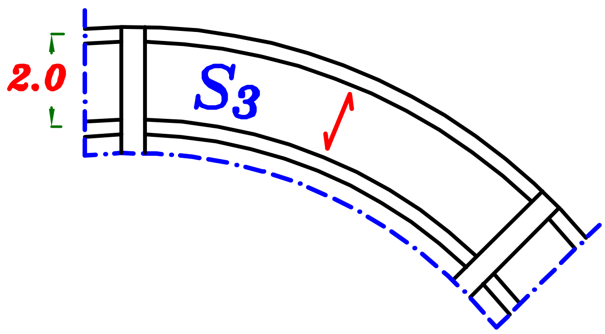


$$S_3 = (9.24\ m * 2.0\ m)$$

$$r = \frac{m * L}{m` * L_s} = \frac{0.76\,(9.24)}{0.87\,(2.0)} = 4.03 > 2.0 \longrightarrow \text{One Way Slab.}$$

S_3 is One Way Slab at 2.0 direction

$$t_{s3} = \frac{L_s}{30} = \frac{2000}{30} = 66.66\ mm$$



Take the bigger value of $t_{s1}, t_{s2}\ \&\ t_{s3}$

Take $t_s = 98.61\ mm$ $\boxed{t_s = 100\ mm}$

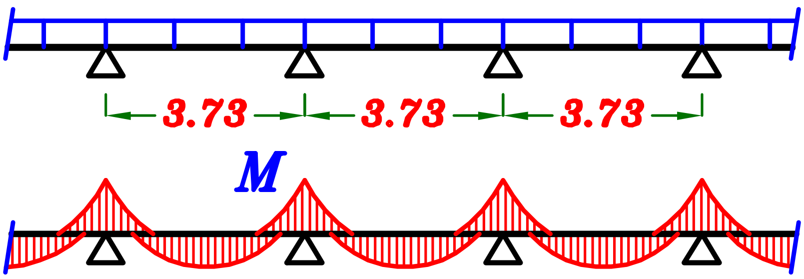
$$w_{sh} = 1.4\,(0.10 * 25 + 1.50) + 1.6\,(1.0) = 7.20\ kN\backslash m^2$$

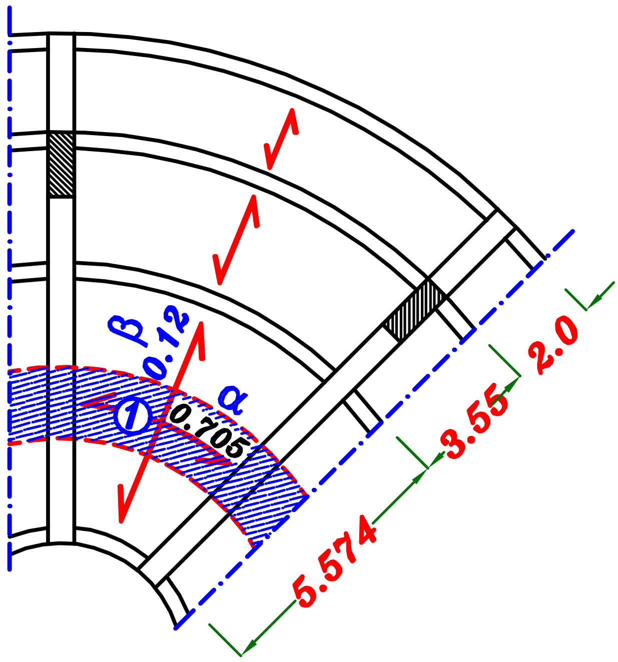
$$w_{si} = 1.4\,(0.10 * 25 + 1.50) + 1.6\,(1.0)\ \text{Cos}\ 9.46^\circ = 7.18\ kN\backslash m^2$$

Strips in the Slabs.

Strip ①

$\alpha\, w_{si} = 0.705 * 7.18 = 5.062$ kN\m





$$M = \frac{w * L^2}{12} = \frac{5.062 * 3.73^2}{12} = 5.87 \text{ kN.m}$$ شريحه أفقيه فى بلاطه مائله

$$M_{des.} = M_{U.L.} \cos\theta = 5.87 * \cos 9.46^\circ = 5.79 \text{ kN.m\m}$$

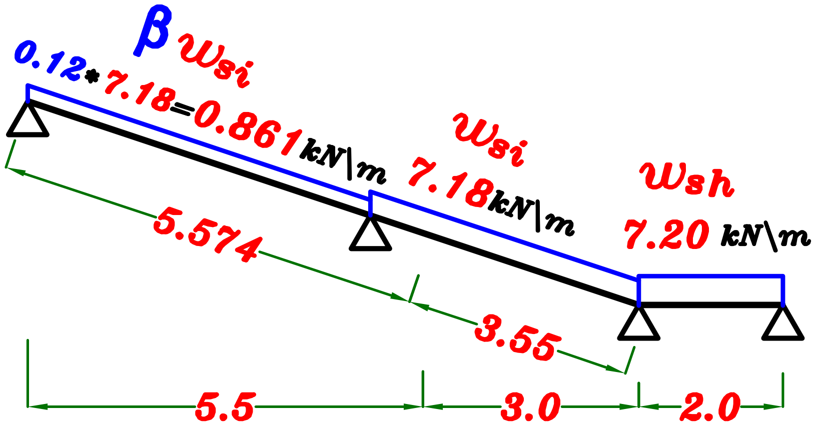
$$t_s = 100 \text{ mm} \quad , \quad d = 100 - 20 = 80 \text{ mm}$$

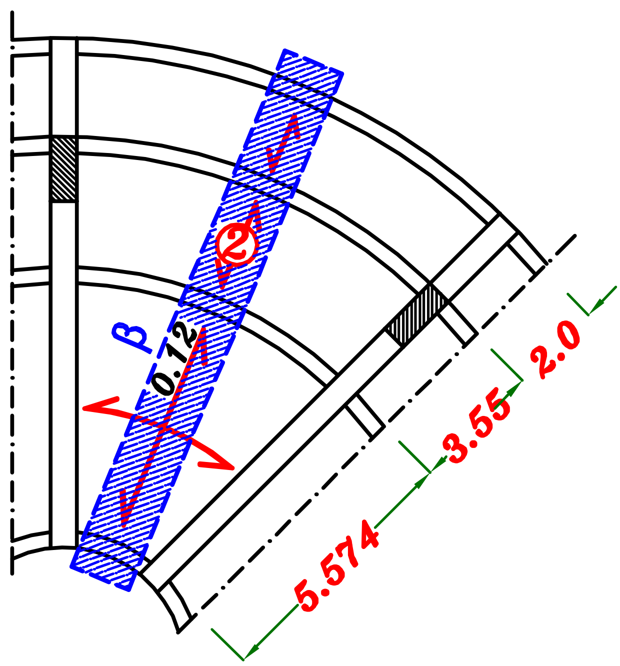
$$80 = C_1 \sqrt{\frac{5.79 * 10^6}{25 * 1000}} \longrightarrow C_1 = 5.25 \longrightarrow J = 0.826$$

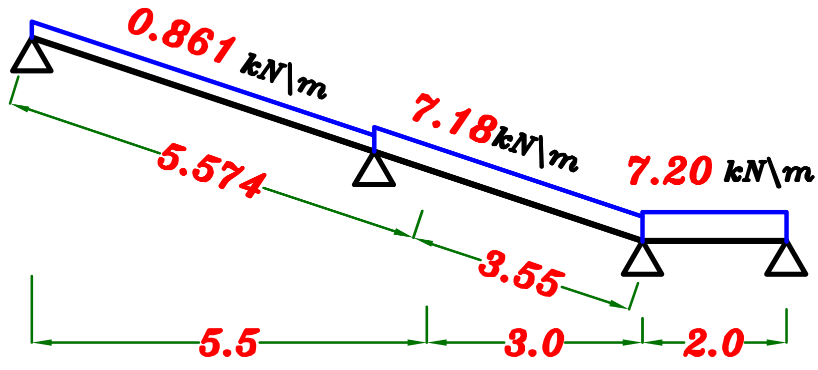
$$A_s = \frac{5.79 * 10^6}{0.826 * 360 * 80} = 243.4 \text{ mm}^2\text{\m}$$

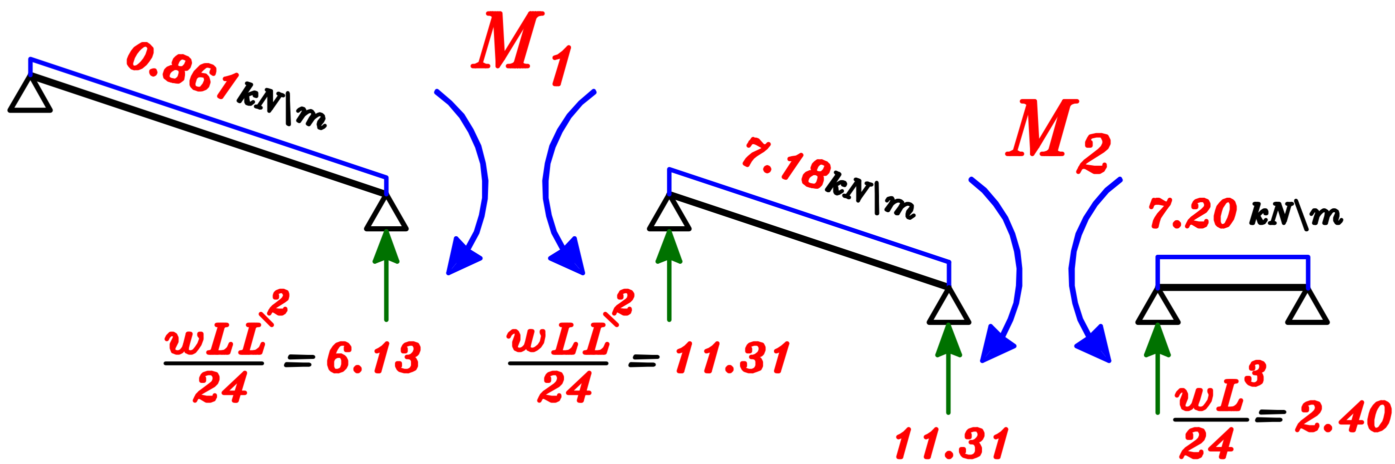
5 ϕ10 \m

Strip ②









$\frac{wLL'^2}{24} = 6.13$ $\frac{wLL'^2}{24} = 11.31$ $\frac{wL^3}{24} = 2.40$

$0.0 + 2 M_1 (5.574 + 3.55) + M_2 (3.55) = -6 (6.13 + 11.31)$

$18.248\ M_1 + 3.55\ M_2 = -104.64$ —— 1

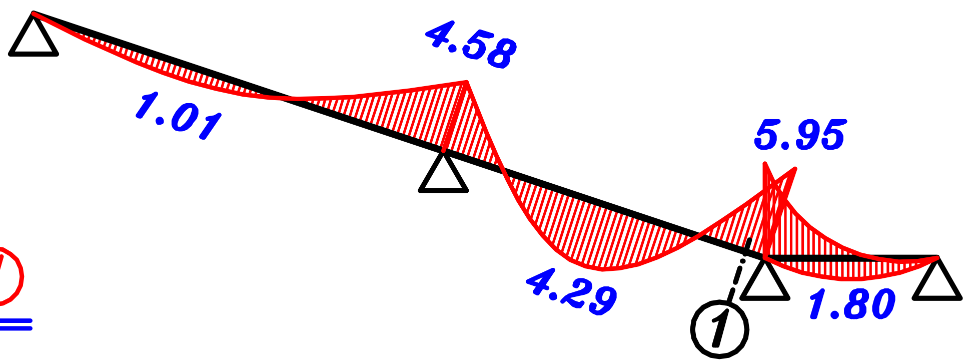
$M_1 (3.55) + 2 M_2 (3.55 + 2.0) + 0.0 = -6 (11.31 + 2.40)$

$3.55\ M_1 + 11.10\ M_2 = -82.26$ —— 2

From 1 , 2

$M_1 = -4.58$

$M_2 = -5.95$

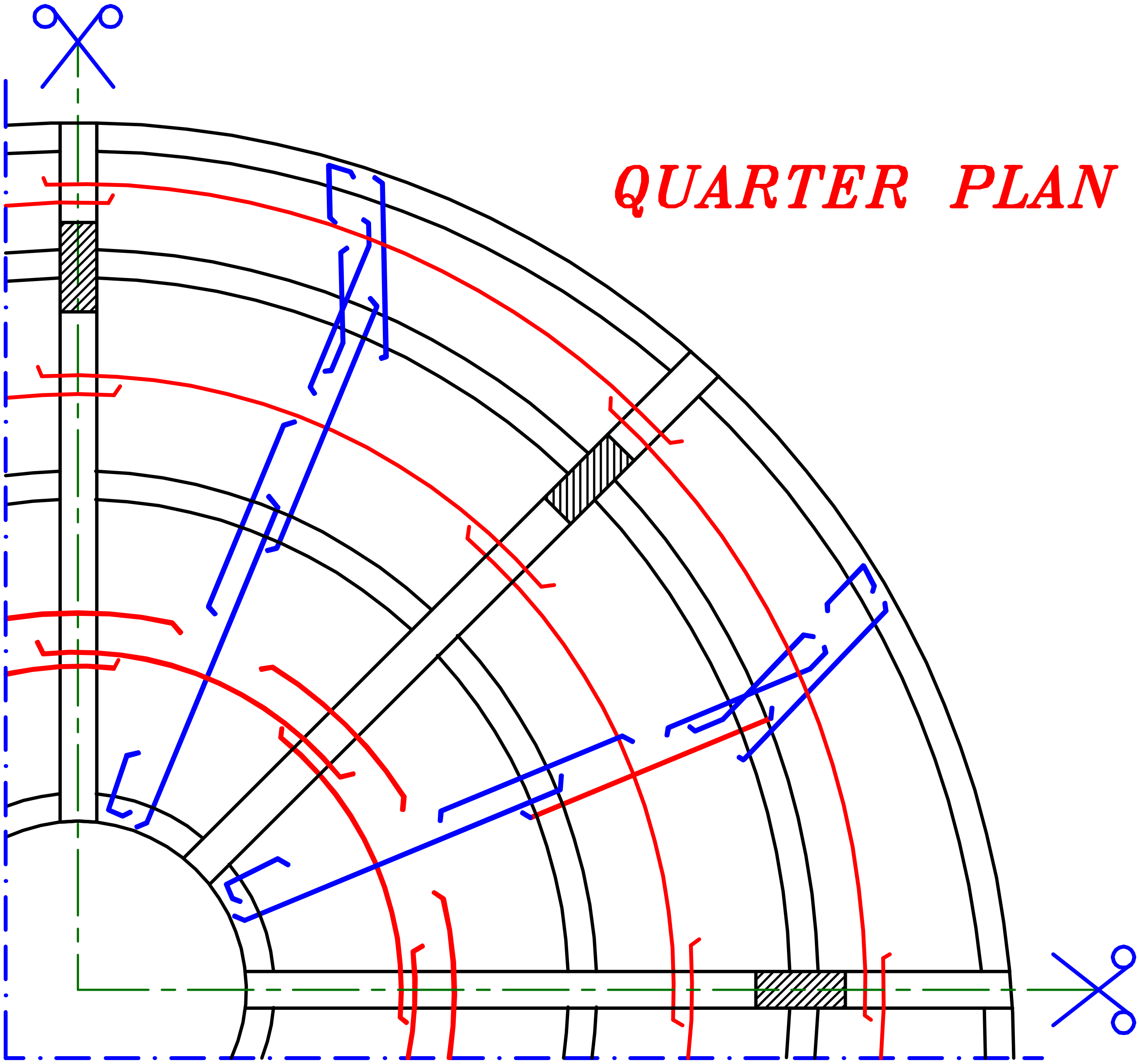


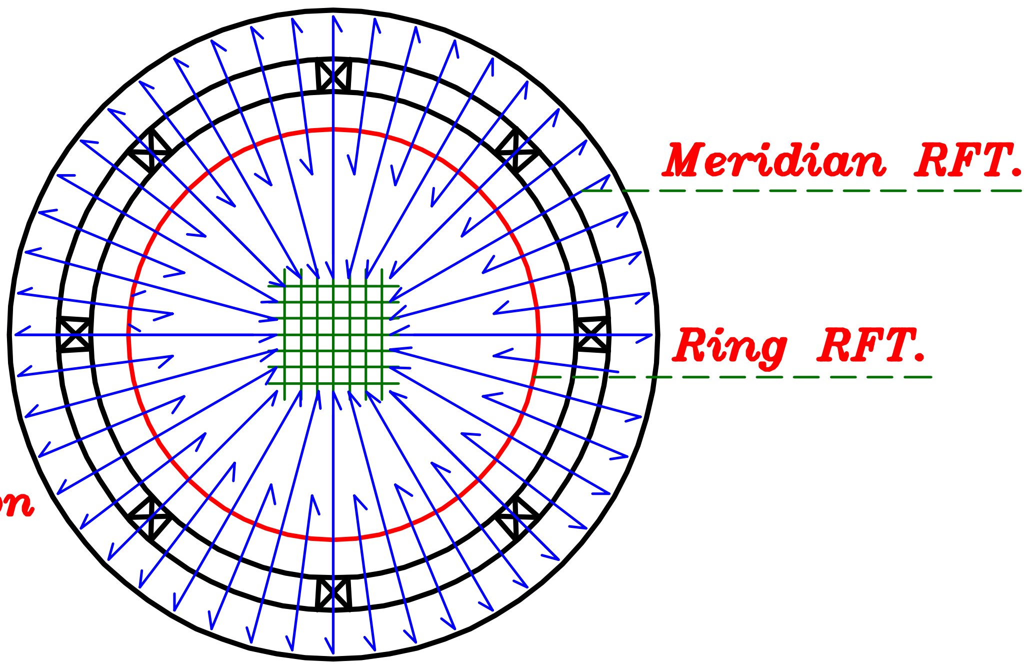
Sec. 1

$t_s = 100\ mm\ ,\ d = 100 - 20 = 80\ mm$

$80 = C_1 \sqrt{\frac{5.95 * 10^6}{25 * 1000}} \longrightarrow C_1 = 5.18 \longrightarrow J = 0.826$

$A_s = \frac{5.95 * 10^6}{0.826 * 360 * 80} = 250.11\ mm\backslash m^2$ $\boxed{5 \phi 10 \backslash m'}$

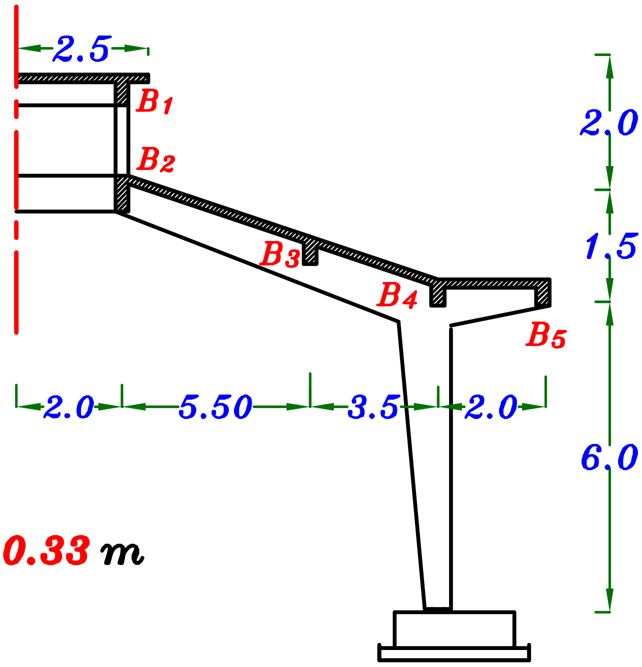




S_4

سيتم دراسه تسليح هذه
البلاطه لاحقا
في درس
Surface of Revolution

Dimensioning & Weight of Ring Beams.



Dimensions of Beams. B_1 & B_2

Span $L = \frac{2 \pi r}{n} = \frac{2 * \pi * 2.0}{8.0} = 1.57\, m$

Take $b = 0.25\, m$

Take $t = \frac{L}{12} + 0.20\, m = \frac{1.57}{12} + 0.20 = 0.33\, m$

Take B_1 & B_2 $(250 * 400)$

$o.w. = 1.4 * b * t * \gamma_c = 1.4 * 0.25 * 0.40 * 25 = 3.50\, kN/m$

Dimensions of Beam B_3

Span $L = \frac{2 \pi r}{n} = \frac{2 * \pi * 7.5}{8.0} = 5.89\, m$

Take $b = 0.30\, m$

Take $t = \frac{L}{12} + 0.20\, m = \frac{5.89}{12} + 0.20 = 0.69\, m$

Take B_3 $(300 * 700)$

$o.w. = 1.4 * b * t * \gamma_c = 1.4 * 0.30 * 0.70 * 25 = 7.35\, kN/m$

Dimensions of Beam B_4

Span $L = \frac{2 \pi r}{n} = \frac{2 * \pi * 11.0}{8.0} = 8.64\, m$

Take $b = 0.30\, m$

Take $t = \frac{L}{12} + 0.20\, m = \frac{8.64}{12} + 0.20 = 0.92\, m$

Take B_4 $(300 * 950)$

$o.w. = 1.4 * b * t * \gamma_c = 1.4 * 0.30 * 0.95 * 25 = 9.975\, kN/m$

Dimensions of Beam B_5

Span $L = \frac{2\pi r}{n} = \frac{2*\pi*13.0}{8.0} = 10.21 \; m$

Take $b = 0.30 \; m$

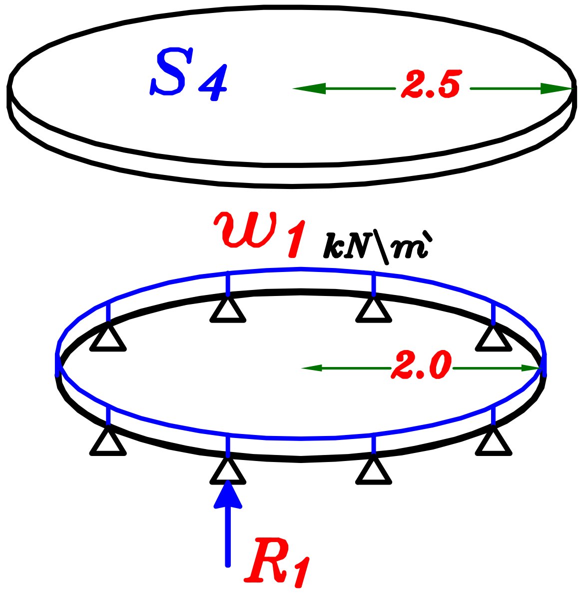
Take $t = \frac{L}{12} + 0.20 \; m = \frac{10.21}{12} + 0.20 = 1.05 \; m$

Take B_5 $(300*1100)$

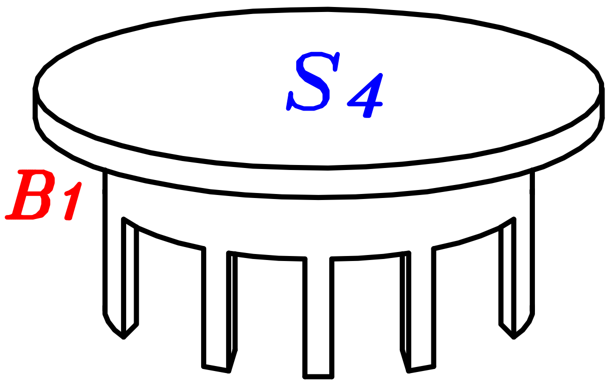
$o.w. = 1.4*b*t*\gamma_c = 1.4*0.30*1.10*25 = 11.55 \; kN/m$

Load Distribution.

Upper Beam B_1 $(250*400)$



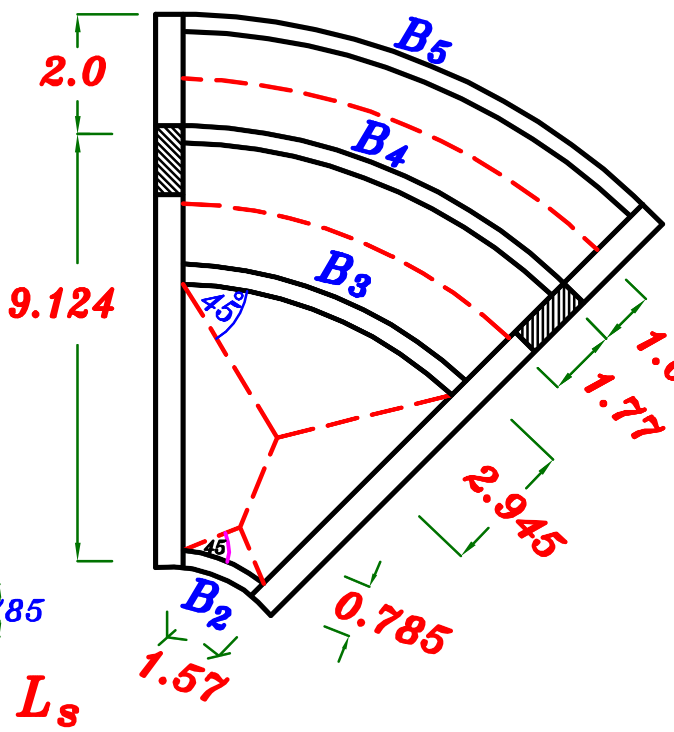
Sky Light

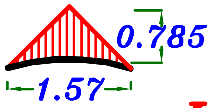


$$w_1 = o.w. + \frac{\pi r^2}{2\pi r_1} * w_{sh}$$

$$w_1 = 3.5 + \frac{\pi (2.5)^2}{2\pi (2.0)} * 7.20 = 14.75 \; kN\backslash m$$

$$R_1 = \frac{w_1 * 2\pi r_1}{n} = \frac{14.75 * 2\pi (2.0)}{8.0} = 23.17 \; kN$$



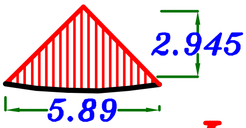


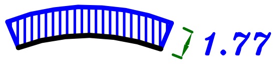
$\underline{\underline{B_2}}$

$$w_2 = o.w. + C_a\, w_{si}\, \frac{L_s}{2}$$

$$w_2 = 3.5 + \frac{1}{2}(7.18)\ 0.785 = 6.32 \ \text{kN}\backslash\text{m}$$

$$R_2 = \frac{w_2 * 2\pi r_2}{n} = \frac{6.32 * 2\pi(2.0)}{8.0} = 9.925 \ \text{kN}$$



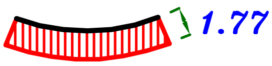


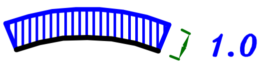
$\underline{\underline{B_3}}$

$$w_3 = o.w. + C_a w_{si}\, \frac{L_s}{2} + w_{si}\, \frac{L_s}{2}$$

$$w_3 = 7.35 + \frac{1}{2}(7.18)\ 2.945 + (7.18)\ 1.77 = 30.63 \ \text{kN}\backslash\text{m}$$

$$R_3 = \frac{w_3 * 2\pi r_3}{n} = \frac{30.63 * 2\pi(7.5)}{8.0} = 180.43 \ \text{kN}$$





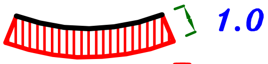
$\underline{\underline{B_4}}$

$$w_4 = o.w. + w_{si}\, \frac{L_s}{2} + w_{sh}\, \frac{L_s}{2}$$

$$w_4 = 9.975 + (7.18)\ 2.945 + (7.20)\ 1.0 = 38.32 \ \text{kN}\backslash\text{m}$$

$$R_4 = \frac{w_4 * 2\pi r_4}{n} = \frac{38.32 * 2\pi(11.0)}{8.0} = 331.06 \ \text{kN}$$

B_5

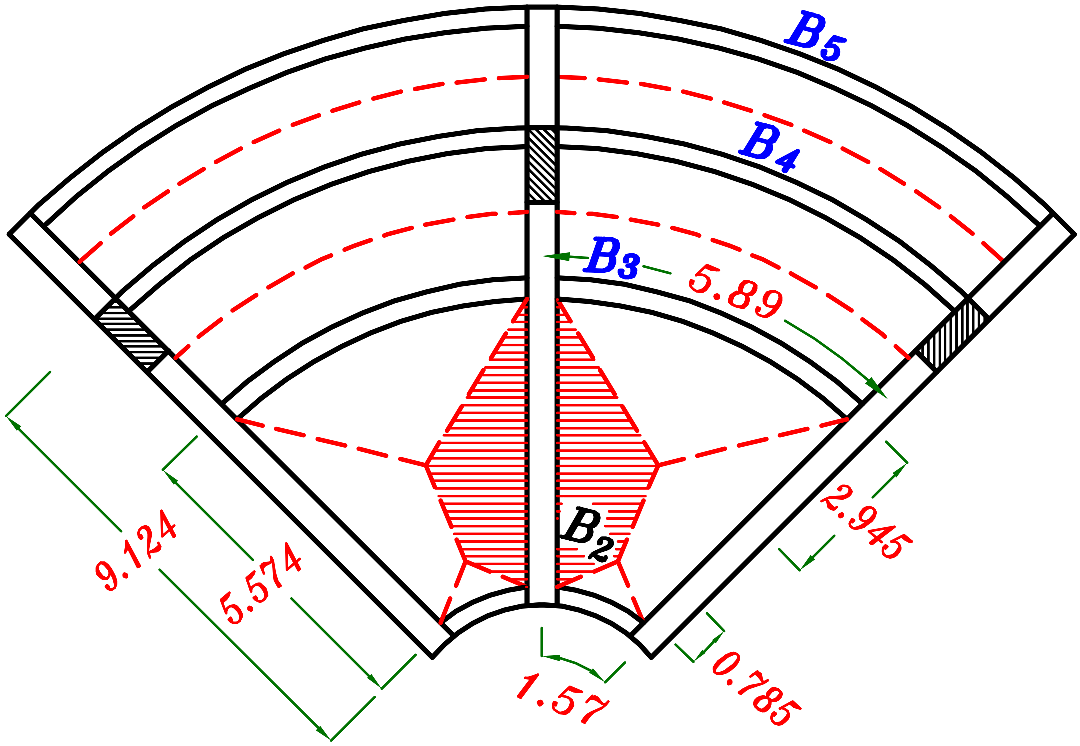


$$w_5 = o.w. + w_{sh}\frac{L_s}{2}$$

$$w_5 = 11.55 + (7.20)\,1.0 = 18.75 \text{ kN\m}$$

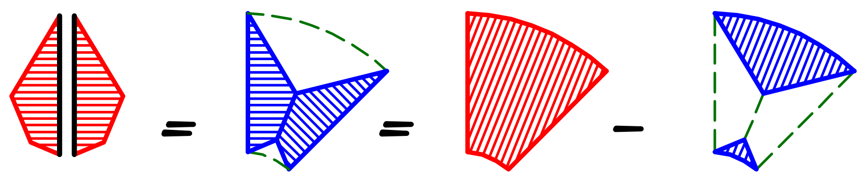
$$R_5 = \frac{w_5 * 2\pi r_5}{n} = \frac{18.75 * 2\pi(13.0)}{8.0} = 191.44 \text{ kN}$$

Loads on Frame. (350*1400)



$$o.w._{(Frame)} = 1.4 * b * t * \gamma_c = 1.4 * 0.35 * 1.40 * 25 = 17.15 \text{ kN/m}$$

$$o.w._{(Post)} = 3.50 \text{ kN } (U.L.)$$

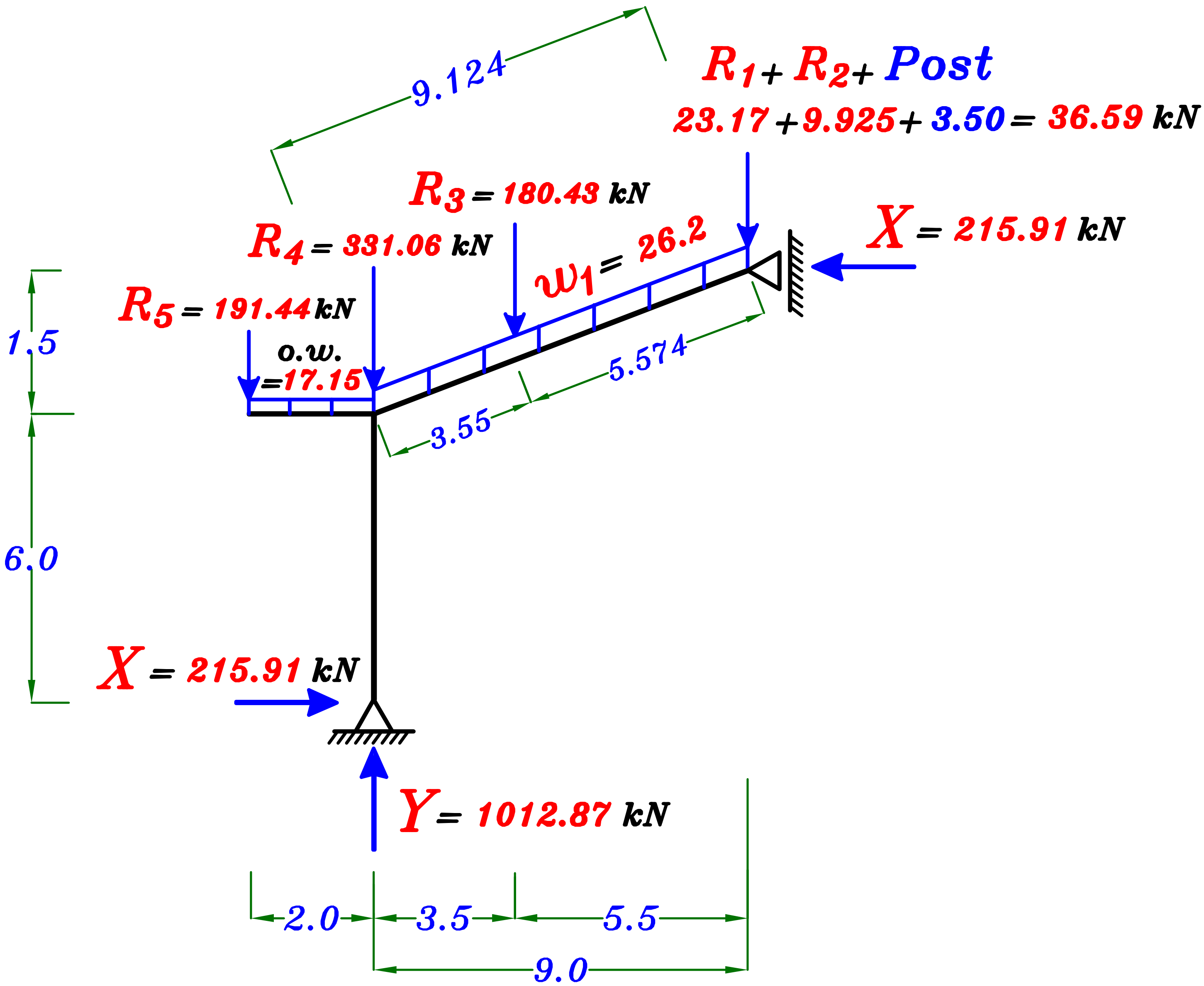
$\Sigma Area =$ 

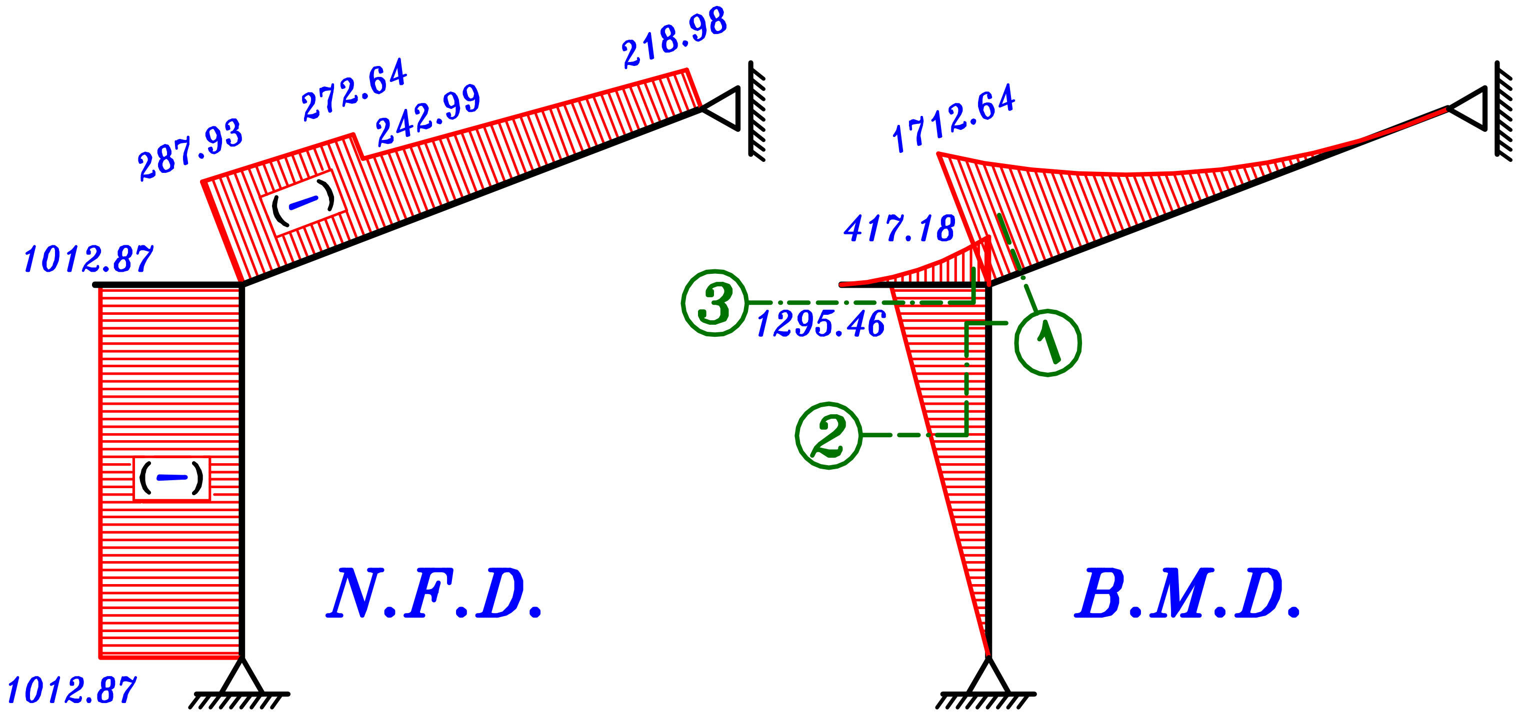
$$\Sigma Area = \left(\frac{L_1 + L_2}{2} * L - \frac{1}{2} L_1 \frac{L_1}{2} - \frac{1}{2} L_2 \frac{L_2}{2}\right)$$

$$= \left(\frac{1.57 + 5.89}{2}\right) * 5.574 - \frac{1}{2}(1.57)(0.785) - \frac{1}{2}(5.89)(2.945) = 11.50 \text{ m}^2$$

$$w_1 = o.w._{(Frame)} + \frac{\sum Area}{Span} * w_{si}$$

$$w_1 = 17.15 + \left(\frac{11.50}{9.124}\right) * 7.18 = 26.20 \ kN\backslash m$$





Design the Frame.

Sec. ① R−Sec. , $b = 350$ mm , $t = 1400$ mm

$M = 1712.64$ kN.m , $P = 287.93$ kN

Check $\dfrac{P}{F_{cu}\, b\, t} = \dfrac{287.93 * 10^3}{25 * 350 * 1400} = 0.0235 < 0.04$ (neglect P)

$\therefore 1300 = C_1 \sqrt{\dfrac{1712.64 * 10^6}{25 * 350}} \longrightarrow C_1 = 2.94 \longrightarrow J = 0.736$

$$\therefore A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{1712.64 * 10^6}{0.736 * 360 * 1300} = 4972.13 \text{ mm}^2$$

Check $A_{s\,min.}$ $A_{s_{req.}} = 4972.13$ mm^2

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 350 * 1200 = 1312.5 \text{ mm}^2$$

$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d$ $\therefore$ Take $A_s = A_{s_{req.}} = 4972.13$ mm^2 11ϕ25

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{350 - 25}{25 + 25} = 7.50 = 7.0 \text{ bars}$$

Stirrup Hangers $= (0.1 \rightarrow 0.2)\, A_s = (0.1 \rightarrow 0.2)\, 4972.13$ 5ϕ12

Sec. ② R-Sec.

$M = 1295.46\ kN.m\ ,\ P = 1012.87\ kN\ ,\ b = 350\ mm\ ,\ t = 1400\ mm$

Check $\frac{P}{F_{cu}\,b\,t} = \frac{1012.87 * 10^3}{25 * 350 * 1400} = 0.082 > 0.04$ (Don't neglect P)

$e = \frac{M}{P} = \frac{1295.46}{1012.87} = 1.279\ m \quad \therefore \frac{e}{t} = \frac{1.279}{1.4} = 0.913 > 0.5 \xrightarrow{use} e_s$

$e_s = e + \frac{t}{2} - c = 1.279 + \frac{1.4}{2} - 0.1 = 1.879\ m$

$M_s = P * e_s = 1012.87 * 1.879 = 1903.18\ kN.m$

$\because d = C_1\sqrt{\frac{M_s}{F_{cu}\,b}} \quad \therefore 1300 = C_1\sqrt{\frac{1903.18 * 10^6}{25 * 350}} \longrightarrow C_1 = 2.78 \longrightarrow J = 0.717$

$$A_s = \frac{M_s}{J\,F_y\,d} - \frac{P_{U.L.}}{(F_y \backslash \gamma_s)} = \frac{1903.18 * 10^6}{0.717 * 360 * 1300} - \frac{1012.87 * 10^3}{(360 \backslash 1.15)} = 2436.16\ mm^2$$

Check $A_{s\,min.}$

$\mu_{min.}\,b\,d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\,d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 350 * 1300 = 1421.87\ mm^2$

$\therefore A_{s\,req.} > \mu_{min.}\,b\,d \quad \therefore$ Take $A_s = A_{s\,req.} = 2436.16\ mm^2$ 5 ϕ25

Sec. ③ R-Sec.

$M = 417.18\ kN.m\ ,\ b = 350\ mm\ ,\ t = 900\ mm$

$\therefore 850 = C_1\sqrt{\frac{417.18 * 10^6}{25 * 350}} \longrightarrow C_1 = 3.89 \longrightarrow J = 0.799$

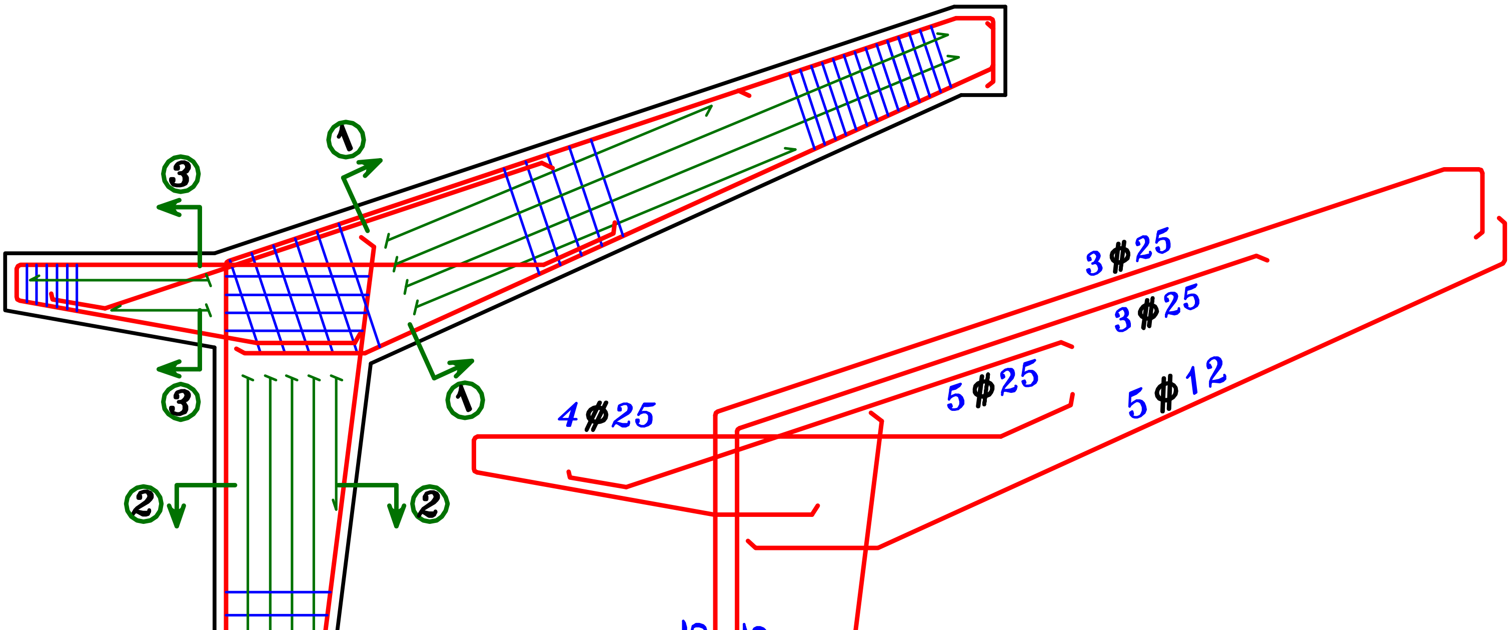
$$\therefore A_s = \frac{M_{U.L.}}{J\,F_y\,d} = \frac{417.18 * 10^6}{0.799 * 360 * 850} = 1706.3\ mm^2$$

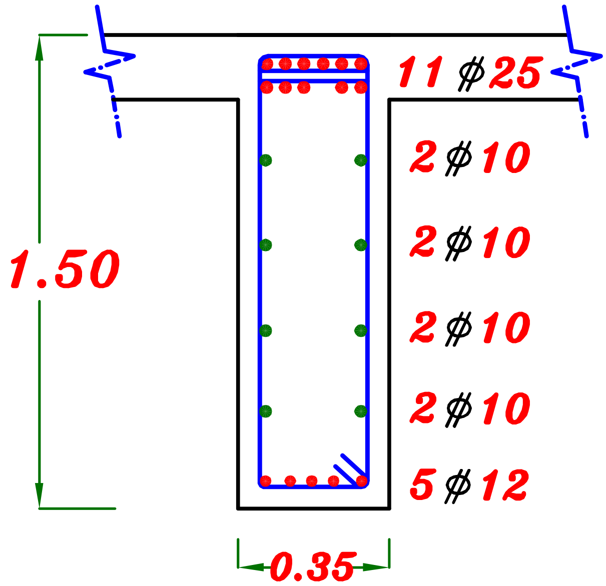
Check $A_{s\,min.}$ $\quad A_{s\,req.} = 1706.3\ mm^2$

$\mu_{min.}\,b\,d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\,d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 350 * 850 = 929.7\ mm^2$

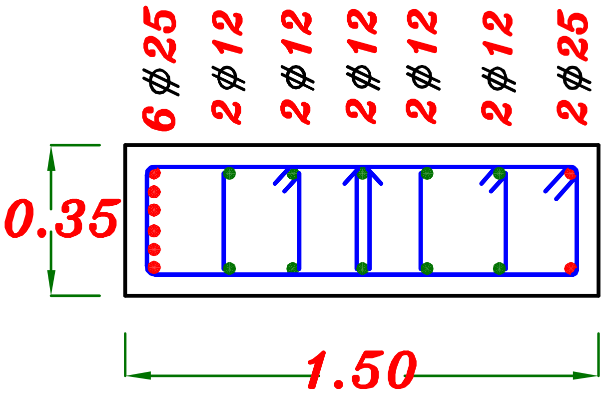
$\therefore A_{s\,req.} > \mu_{min.}\,b\,d \quad \therefore$ Take $A_s = A_{s\,req.} = 1706.3\ mm^2$ 4 ϕ25

RFT. of Frame.

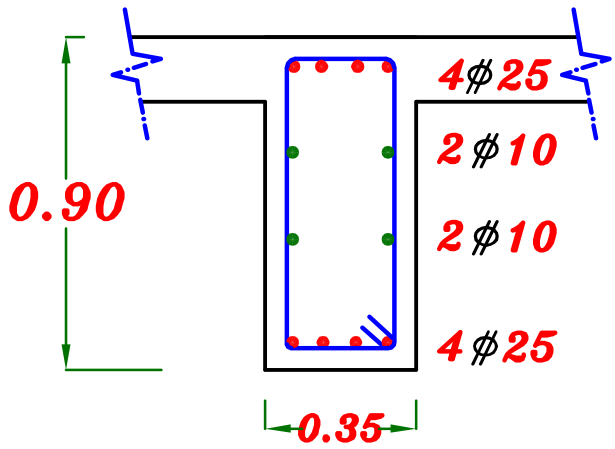




Sec. (1–1)



Sec. (2–2)

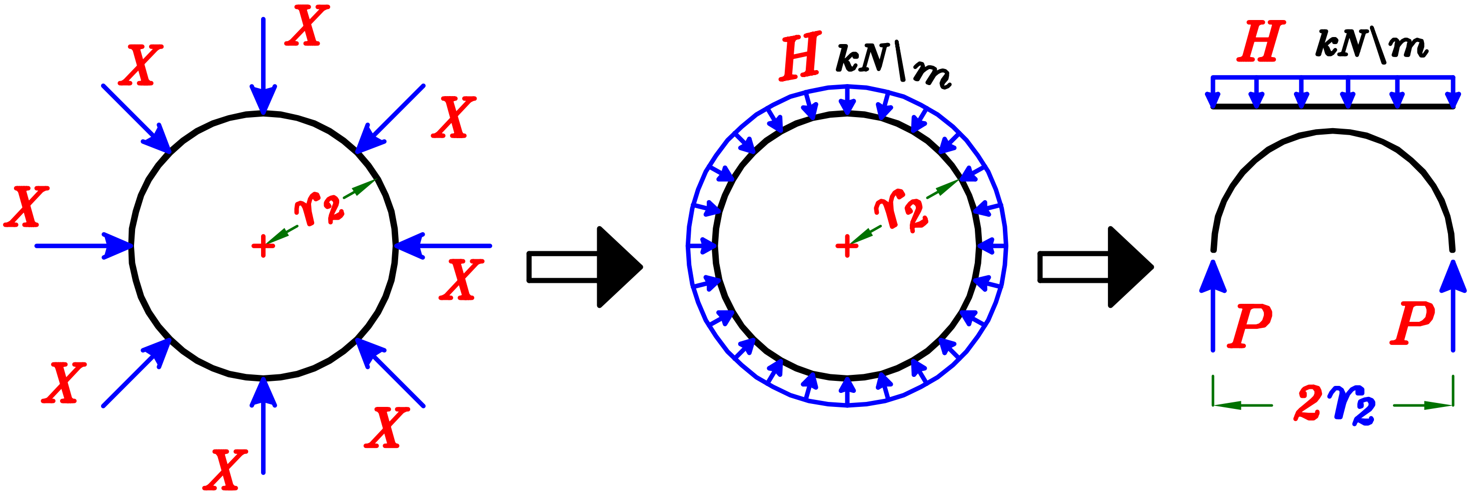


Sec. (3–3)

Design of Ring Beams.

و فى هذا المثال سنصمم كمرتين B_2 & B_4 فقط

B_2 (250*400) $r_2 = 2.0$ m $X = 215.91$ kN $n = 8$



$$H = \frac{\sum X}{2\pi r_2} = \frac{8.0 * 215.91}{2\pi * 2.0} = 137.45 \text{ kN/m}$$

$$P = H * r_2 = 137.45 * 2.0 = 274.9 \text{ kN}$$

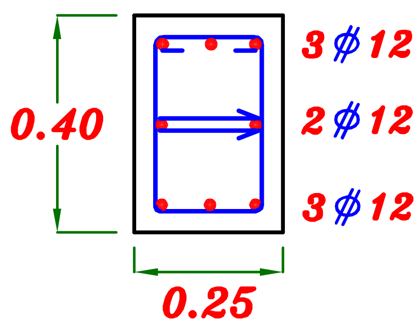
Designed as short Column.

$$P_{U.L.} = 0.35\ A_c\ F_{cu} + 0.67\ A_s\ F_y$$

$$274.9 * 10^3 = 0.35\ (250 * 400) * 25 + 0.67\ A_s * 360$$

$$A_s = -2488\ mm^2 < A_{s\,min}$$

$$A_s = A_{s\,min} = \frac{0.8}{100} * (250 * 400) = 800\ mm^2 \quad \boxed{8 \phi 12}$$



$\underline{\underline{B_4}}$ (300 * 950) $w_2 = 38.32$ kN\m $r_4 = 11.0$ m

$$P = w_4(2\pi r_4) = 38.32(2\pi * 11.0) = 2648.5 \text{ kN}$$

From old Table Page 120 $n = 8.0$

No. of supports	Load on each support	Max. Shearing Force	Max. Bending Moment at C.L. of Span	Max. Bending Moment Over C.L. of Column	Max. Torsional Moment	Centeral angel
n	R	$Q_{max.}$	M +Ve	M −Ve	$M_{t\,max.}$	θ
4	P/4	P/8	0.0176 Pr	− 0.0322 Pr	0.0053 Pr	19° 21`
6	P/6	P/12	0.0075 Pr	− 0.0148 Pr	0.0015 Pr	12° 44`
8	P/8	P/16	0.0042 Pr	− 0.0083 Pr	0.0006 Pr	9° 33`
10	P/10	P/20	0.0032 Pr	− 0.0052 Pr	0.0004 Pr	7° 36`
12	P/12	P/24	0.0019 Pr	− 0.0037 Pr	0.0002 Pr	6° 21`

$$\text{max. } M_{+Ve} = 0.0042\,Pr = 0.0042 * 2648.5 * 11.0 = 122.36 \text{ kN.m}$$

$$\text{max. } M_{-Ve} = 0.0083\,Pr = 0.0083 * 2648.5 * 11.0 = 241.80 \text{ kN.m}$$

$$\text{max. } M_t = 0.0006\,Pr = 0.0006 * 2648.5 * 11.0 = 17.48 \text{ kN.m}$$

$$Q_{max.} = \frac{P}{16} = \frac{2648.5}{16} = 165.53 \text{ kN}$$

Centeral angel $\theta = 9^\circ 33` = 9.55^\circ$

$$X = r * \theta * \frac{\pi}{180} = 11.0 * 9.55 * \frac{\pi}{180} = 1.83 \text{ m}$$

$$Q_{cor.} = Q_{max} - w * X = 165.53 - 38.32 * 1.83 = 95.40 \text{ kN}$$

Design beam B4 $\quad b = 300\ mm\ ,\ t = 950\ mm$

Sec. of max. $-Ve$ B.M. $\quad M = 241.80\ kN.m.$

$$\therefore\ d = C_1\sqrt{\frac{M_{U.L.}}{F_{cu}\ b}} \quad \therefore\ 900 = C_1\sqrt{\frac{241.80 * 10^6}{25 * 300}} \rightarrow C_1 = 5.01 \rightarrow J = 0.826$$

$$\therefore\ A_s = \frac{M_{U.L.}}{J\ F_y\ d} = \frac{241.80 * 10^6}{0.826 * 360 * 900} = 903.5\ mm^2$$

Check $A_{s_{min.}}$ $\quad A_{s_{req.}} = 903.5\ mm^2$

$$\mu_{min.}\ b\ d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\ d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 300 * 900 = 843.7\ mm^2$$

$$\therefore\ A_{s_{req.}} > \mu_{min.}\ b\ d \quad \therefore\ \text{Take } A_s = A_{s_{req.}} = 903.5\ mm^2$$

Sec. of max. $+Ve$ B.M. $\quad M = 122.36\ kN.m.$

$$\therefore\ d = C_1\sqrt{\frac{M_{U.L.}}{F_{cu}\ b}} \quad \therefore\ 900 = C_1\sqrt{\frac{122.36 * 10^6}{25 * 300}} \rightarrow C_1 = 7.04 \rightarrow J = 0.826$$

$$\therefore\ A_s = \frac{M_{U.L.}}{J\ F_y\ d} = \frac{122.36 * 10^6}{0.826 * 360 * 900} = 457.21\ mm^2$$

Check $A_{s_{min.}}$ $\quad A_{s_{req.}} = 457.21\ mm^2$

$$\mu_{min.}\ b\ d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\ d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 300 * 900 = 843.7\ mm^2$$

$$\therefore\ \mu_{min.}\ b\ d > A_{s_{req.}} \xrightarrow{\text{Use}} A_{s_{min.}}$$

$$A_{s_{min.}} = 0.225 * \frac{\sqrt{F_{cu}}}{F_y}\ b\ d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 300 * 900 = 843.7$$

$$1.3\ A_{s_{req.}} = 1.3 * 457.21 = 594.3$$

الأقل $= 594.3$

st. 360/520 $\quad \frac{0.15}{100}\ b\ d = \frac{0.15}{100} * 300 * 900 = 405\ mm^2$

الأكبر $= 594.3\ mm^2$

Design due to Shear & Torsion.

$b = 300\ mm\ ,\ t = 950\ mm$

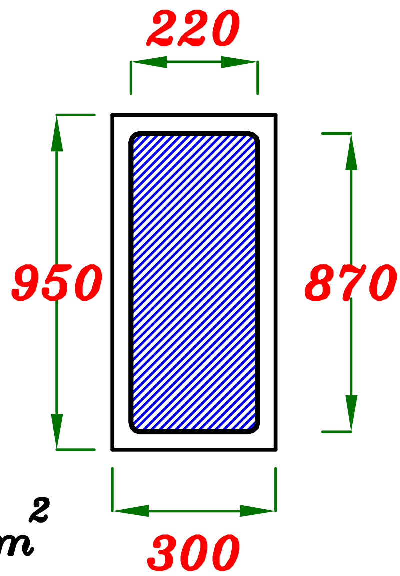
$$q_u = \frac{Q}{b\,d} = \frac{95.40 * 10^3}{300 * 900} = 0.353\ N/mm^2$$

$$A_{oh} = 220 * 870 = 191400\ mm^2$$

$$A_o = 0.85 * A_{oh} = 0.85 * 191400 = 162690\ mm^2$$

$$P_h = 2 * 220 + 2 * 870 = 2180\ mm$$

$$t_e = \frac{A_{oh}}{P_h} = \frac{191400}{2180} = 87.80\ mm$$



$$q_{tu} = \frac{M_{tu}}{2\,A_o\,t_e} = \frac{17.48 * 10^6}{2 * 162690 * 87.80} = 0.611\ N/mm^2$$

$$q_{cu} = (0.24)\sqrt{\frac{25}{1.5}} = 0.98\ N/mm^2$$

$$q_{t\,min} = (0.06)\sqrt{\frac{25}{1.5}} = 0.245\ N/mm^2$$

$$q_{u\,max} = (0.7)\sqrt{\frac{25}{1.5}} = 2.85\ N/mm^2$$

$$\sqrt{q_u^2 + q_{tu}^2} = \sqrt{0.353^2 + 0.611^2} = 0.705\ N/mm^2 < q_{u\,max}\ \therefore\ o.k.$$

$\boxed{q_u < q_{cu}\ ,\ q_{tu} > q_{t\,min}}$ $\therefore$ Use RFT. For Torsion only.

* **Stirrups.**

$$\because A_{str} = \frac{M_{tu}\ S_t}{(1.7)\ A_{oh}\ \left(\frac{F_y}{\gamma_s}\right)} \qquad \therefore A_{str} = \frac{17.48 * 10^6 * S_t}{(1.7)(191400)(240/1.15)}$$

$$\therefore \boxed{S_t = 3.88 * A_{str}}$$

* Take $\phi\ 8 \longrightarrow A_{str} = 50.3\ mm^2$

$$\therefore S_t = 3.88 * A_{str} = 3.88 * 50.3 = 195.16\ mm > 100\ mm \quad \therefore o.k.$$

$$\therefore \text{No. of stirrups}\backslash m' = \frac{1000}{S} = \frac{1000}{195.16} = 5.12 = 6.0$$

$\therefore$ Use Closed Stirrups $\boxed{6\ \phi\ 8 \backslash m'}$ 2 branches.

* **Longitudinal Bars.**

$$S_t = \frac{1000}{6} = 166.66\ mm$$

$$A_{sl} = \frac{A_{str} * P_h}{S_t}\left(\frac{F_{y\ str.}}{F_{y\ L.b.}}\right) = \frac{(50.3 * 2180)}{166.66}\left(\frac{240}{360}\right) = 438.6\ mm^2$$

$$\therefore \frac{A_{sl}}{4} = \frac{438.6}{4} = 109.65\ mm^2$$

$$A_{s\ -Ve} = A_s + \frac{A_{sl}}{4} = 903.5 + 109.65 = 1013.15\ mm^2$$

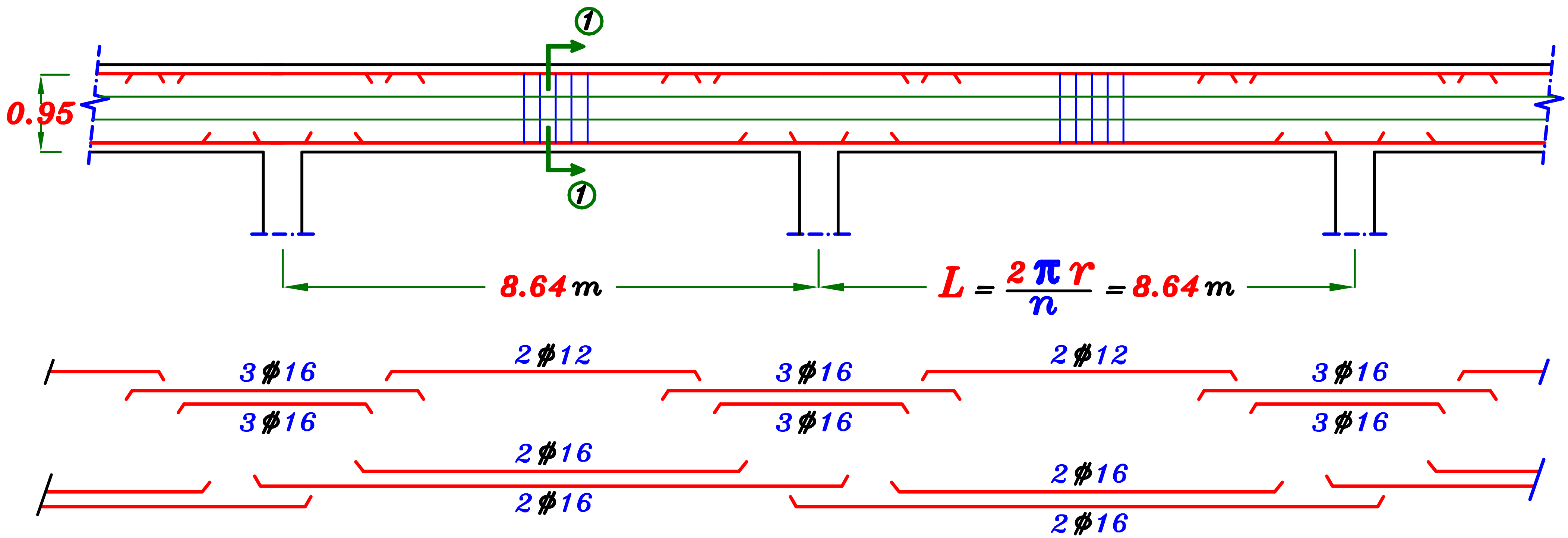
6 ϕ 16

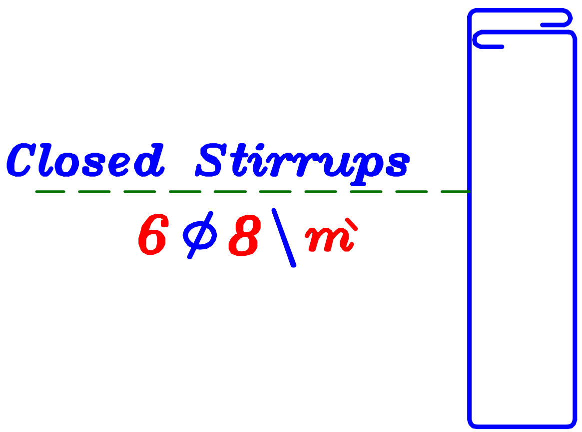
$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{300 - 25}{16 + 25} = 6.70 = 6.0$$

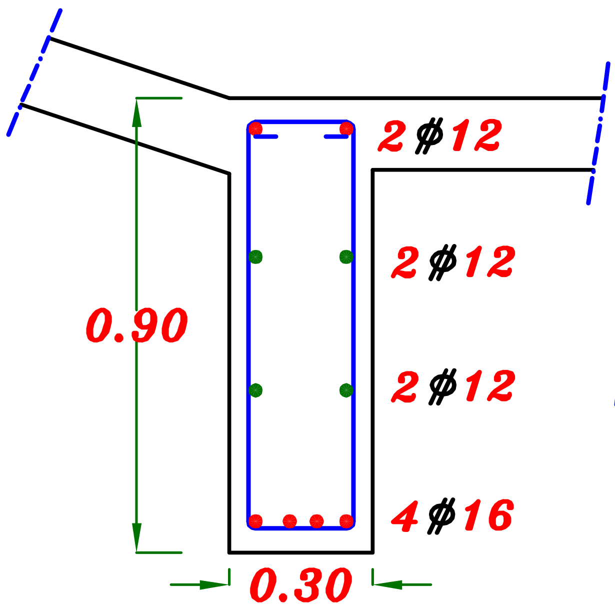
$$A_{s\ +Ve} = A_s + \frac{A_{sl}}{4} = 594.3 + 109.65 = 703.95\ mm^2$$

4 ϕ 16

Developed Elevation of Beam B_4







Sec. (1–1)